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Agricultural Productivity and Policies in Sub-Saharan Africa

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ABSTRACT

We analyze the evolution of Sub-Saharan Africa's (SSA's) agricultural total factor productivity (TFP) over the past 45 years, looking for evidence of recent changes in growth patterns using an improved nonparametric Malmquist index. Our TFP estimates show a remarkable recovery in the performance of SSA's agriculture between 1984 and 2006 after a long period of poor performance and decline. That recovery is the consequence of improved efficiency in production, resulting from changes in the output structure and an adjustment in the use of inputs. Policy interventions, including fiscal, trade, and sector-specific policies, appear to have played an important role in improving agricultural performance. Despite the improved agricultural performance, economies in SSA face serious challenges to sustain growth. Among these are the small contribution of technological change to TFP growth in the past, the large tax burden imposed by remaining distortions, and the challenge of population growth.

Keywords: agriculture, efficiency, Malmquist index, total factor productivity, technical change, Sub-Saharan Africa, policy

1. INTRODUCTION

Sub-Saharan Africa (SSA) is the most important development challenge of the 21st century. This region has been lagging behind the rest of the developing world in terms of economic growth and poverty alleviation, widening the gap between SSA and emerging developing countries. Gross domestic product (GDP) per capita was only $612 (constant 2000 U.S. dollar value)[1] in 2009, which is less than one-third of the level in developing East Asia. As a result, 29 of the world's 40 low-income countries are in this subcontinent, and countries with the highest rates of malnutrition can be found here as well.

Economies in SSA have exhibited impressive performance in recent years, growing at 6 percent per year. This brings widespread optimism among researchers and policymakers, fueled by the end of several civil wars, a wave of democratization in several countries (which made possible the creation of the New Partnership for Africa's Development, or NEPAD, and a new agenda for development), the acceleration of economic growth, and significant improvements in the performance of the agricultural sector across Africa during the 1980s and 1990s.

The agricultural sector is predominant in most SSA economies, contributing more than one-third of the regional gross national product (GNP) and employing more than two-thirds of the labor force (World Bank 2010). Agriculture is also one of the major sources of foreign exchange earnings. In spite of its central role in the region's economy, the agricultural sector has not experienced a performance as encouraging as that of other developing countries, as evidenced by the low cereal yield and high reliance on grain imports. On the other hand, low inherent soil fertility, together with increased population pressure, has caused soil degradation and nutrient depletion across much of the continent.

In the long run, sustainable agricultural growth can only be achieved through increased total factor productivity (TFP), the amount of output per unit of total factors used in the production process (Winters et al. 1998). A more efficient use of resources becomes increasingly important as countries begin to face resource constraints. Despite evidence of improved performance in the past 10 years, only a few studies have attempted to analyze SSA's agricultural productivity changes and the factors explaining those changes. Most studies have shown evidence of recovery in Africa. However, estimates of the magnitude of productivity growth vary depending on the analytical methodology and sample.

Block (1995) found agricultural productivity growth rates during the 1970s to be disappointing although 39 SSA countries grew at approximately 1.6 percent per year from 1983 to 1988. Lusigi and Thirtle (1997) suggested that average growth in productivity for 47 African countries was 1.27 percent per year in the period 1961–1991. Fulginiti, Perrin, and Yu (2004) found no signs of sustained growth in productivity during the 1960s and 1970s, but with productivity growth picking up after 1984, the authors reported total gains of 0.83 percent for 41 SSA countries between 1960 and 1999. Between 1985 and 1999, they found that productivity rose by 1.9 percent per year. They also found evidence of fairly strong growth during the 1980s and 1990s, with annual growth rates of 1.29 and 1.62 percent, respectively.

In contrast, Trueblood and Coggins (2003) claimed that although selected countries showed signs of recovery in the 1980s, the SSA regional aggregate productivity had declined by an average of 0.9 percent. They attributed those losses to, among other things, the choice of the technology frontier, which is defined by the most efficient countries in the sample. Instead of using SSA countries as reference, as did Fulginiti, Perrin, and Yu (2004), Trueblood and Coggins used a global average. Similarly, based on a global sample, Coelli and Prasada Rao (2005) reported that 6 out of 18 African countries had a productivity growth rate above 2 percent during the 1980–2000 period.

Recently, Evenson and Dias Avila (2007) estimated the average TFP growth for Africa (including North Africa) at 1.68 percent per year in the period 1981–2001, higher than what they found for the 1961–1980 period (1.20 percent). Following the same fixed input cost shares, a slightly lower productivity growth rate of 1.2 percent was reported by Fuglie (2008) for SSA since 1990. Alene (2010) found that SSA agricultural productivity grew at 1.6 percent per year during 1970–2004, based on a

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[1] All dollar amounts are in international dollars, equivalent to the purchasing power of the U.S. dollar in 2000.

sequential technology frontier approach. In a recent paper, Block (2010) revisited agricultural productivity growth in SSA and found that TFP growth had increased rapidly since the early 1980s following a period of nearly 20 years of declining rates of TFP. Block associated this improved performance with expenditures on agricultural research and development (R&D), along with the reform of macroeconomic and sectoral policies that enhanced agricultural incentives.

In addition, researchers have examined whether the source of growth is technological change or purely gains in efficiency. Lusigi and Thirtle (1997) argued that the majority of countries with higher labor-to-land ratios experienced higher gains in technological progress while most countries with lower ratios experienced more improvement in efficiency scores. Nin-Pratt and Yu (2008) indicated that productivity recovery was the consequence of improved efficiency in production, resulting from changes in the output structure and an adjustment in the use of inputs, including increased fertilizer use in most of the best-performing countries despite an overall net reduction in fertilizer use. In contrast, Alene (2010) found that technological progress, rather than a change in efficiency, was the principal source of productivity growth in SSA.

Empirical evidence on factors explaining the recovery of African agricultural productivity is sparse, with most studies looking at the relationship between productivity and policy reforms. Block (1995) found that almost two-thirds of TFP growth could be explained by macroeconomic policy changes. Similarly, Nin-Pratt and Yu (2008) found that policy changes implemented in the mid-1980s and the second half of the 1990s, combined with technological innovations available at that time, appear to have played an important role in improving agricultural performance.

Investment in agricultural R&D also made a significant contribution to productivity growth according to both Block (1995) and Lusigi and Thirtle (1997). This is confirmed by Alene (2010) concurred, finding that agricultural R&D and improved weather, together with policy reforms, contributed to the recovery of agricultural productivity. Other factors associated with productivity growth include institutions (Fulginiti, Perrin, and Yu 2004) and population pressure (Lusigi and Thirtle 1997).

Generally speaking, negative productivity growth rates have been observed during the 1960s and 1970s. Agricultural productivity has risen since the mid-1980s, with growth rates in TFP ranging between 0.5 and 2 percent per year, a clear improvement from growth rates observed in the earlier years. Possible factors that explain TFP growth include policy and agricultural R&D.

This study focuses on analyzing policy changes and investments that lie behind the recovery of SSA's agricultural sector, answering two questions: Which policy changes were behind SSA's agricultural recovery? Which policies and investment are needed to sustain agricultural TFP growth in the coming years? We examine the impact of macro and sectoral policies on agricultural productivity growth, and also the role of trade policies in SSA's export diversification and insertion in world markets. First, we estimate a nonparametric Malmquist index and its components (efficiency and technological change). Instead of fixed input cost share, which has been used by other researchers, we constrain the shadow input shares in the estimation of distance functions to rule out the possibility of zero-input shadow prices. Next, we update the study by Nin-Pratt and Yu (2008) by using a group of policy indicators to determine the contribution of policies to the improved performance of SSA's agricultural sector.

This paper makes several contributions to the literature on agricultural productivity in SSA. First, it expands the existing literature by bringing new evidence to investigate the factors behind the dynamism of agriculture and the possible linkage between agricultural growth and policy changes. Second, it confirms the improved performance of SSA's agriculture since the mid-1980s measured in terms of TFP growth. Third, it is able to quantify the impact of various policies on productivity, suggesting that more a favorable policy environment has contributed to the recent recovery in agriculture.

The paper is organized as follows. The next section presents the methodology employed and the data used to estimate agricultural TFP. Section 3 presents productivity estimates and discussion of results, and Section 4 presents main findings from the literature on SSA's policies in past decades. This is followed in Section 5 by results of the estimation of an econometric model relating agricultural TFP series with measures of policies. The last section summarizes main findings and concludes.

2. PRODUCTIVITY MEASURES AND METHODOLOGY

Productivity change is defined as the ratio of change in output to change in input. In the hypothetical case of a production unit using one input to produce one output, the measure of productivity is fairly simple to derive. However, production units can use multiple inputs to produce one or more outputs, and under such circumstances the primary challenge in measuring TFP arises from the need to aggregate different inputs and outputs, an aggregation that is both conceptually and empirically difficult. Several methods to aggregate inputs and outputs are available, resulting in different approaches to measuring TFP. Such methods can be classified into four major groups: (a) econometric production models, (b) TFP indexes, (c) data envelope analyses (DEAs), and (d) stochastic frontiers.

The Malmquist index, pioneered by Caves, Christensen, and Diewert (1982) and based on distance functions, has been extensively used in the measure and analysis of productivity after Färe et al. (1994) showed that the index can be estimated using DEA, a nonparametric approach. The nonparametric Malmquist index has been especially popular because it is easy to compute and does not require information about input or output prices or assumptions regarding economic behavior, such as cost minimization and revenue maximization. This is especially attractive in the context of African agriculture, where input market prices are either nonexistent or insufficiently reported to provide any meaningful information for land, labor, and livestock. The Malmquist index approach is chosen for its ability to decompose productivity growth into two mutually exclusive and exhaustive components: changes in technical efficiency over time (catching up) and shifts in technology over time (technological change).

The Malmquist TFP Index

The Malmquist index measures the TFP change between two data points (e.g., those of a country in two different time periods) by calculating the ratio of the distance of each data point relative to a common technological frontier. Following Färe et al. (1994), the Malmquist index between period *t* and *t* + 1 is given by

$$M = \left[M^{t} \times M^{t+1}\right]^{1/2} = \left[\frac{D^{t}(x^{t+1}, y^{t+1})}{D^{t}(x^{t}, y^{t})} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t}, y^{t})}\right]^{1/2} \quad (1)$$

.

This index is estimated as the geometric mean of two Malmquist indexes, one using as a reference the technology frontier in t $\left(M^{t}\right)$ and the second using the frontier in t + 1 $\left(M^{t+1}\right)$. The distance function $D^{t}(x^{t}, y^{t})$ measures the distance of a vector of inputs (x) and outputs (y) in period t to the technical frontier in the same period t. On the other hand, $D^{t+1}(x^{t}, y^{t})$ measures the distance between the same vector of inputs and outputs in period t, but in this case to the frontier in period t + 1. The other two distances can be explained in the same fashion.

Färe et al. (1994) showed that the Malmquist index could be decomposed into an efficiency change component and a technical change component, and that these results would apply to the different period-based Malmquist indexes. It follows that

$$M = \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t}(x^{t}, y^{t})} \times \left[\frac{D^{t}(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^{t}(x^{t}, y^{t})}{D^{t+1}(x^{t}, y^{t})}\right]^{1/2} \quad (2)$$

.

The ratio outside the square brackets measures the change in technical efficiency from period *t* to *t* + 1, or how far the observed production is from maximum potential production. The expression inside the brackets measures technical change, capturing the shift in the technology frontier between the two periods. If the efficiency change index value is greater than one, it means that the production unit is closer to the frontier in period $t + 1$ than it was in period t—in other words, that the production unit is catching up to the frontier. A value of less than one indicates efficiency regress. The same holds for the technical change component of total productivity growth, signifying technical progress when the value is greater than one and technical regress when it is less than one.

However, as Nin, Arndt, and Preckel (2003) showed, the DEA approach used to estimate distances defines the frontier as a sequential frontier, ruling out the possibility of technical regress. The method has been extensively applied to the international comparison of agricultural productivity.

To define the input-based Malmquist index, it is necessary to define and estimate the distance functions *D*, which requires a characterization of the production technology and production efficiency. Following Kuosmanen, Post, and Sipiläinen (2004), we are formally defining technology and efficiency, and relating this measure with allocative efficiency and an economic measure of performance. This approach allows us to highlight the importance of shadow prices in the nonparametric estimation of distance functions and to be able to introduce new information in the estimation of distance functions to avoid the bias caused by zero shadow prices.

Technology and Distance Functions

We assume, as did Färeet al. (1994), that for each time period $t = 1, \ldots, T$ the production technology describes the possibilities for the transformation of inputs x^t into outputs y^t, or the set of output vectors $\mathbf{y}$ that can be produced with input vector $\mathbf{x}$. The technology in period t with $y^t \in R_+^m$ outputs and $x^t \in R_+^n$ inputs is characterized by the production possibility set as follows:

$$L^t = \{(y^t, x^t)\text{: such that } x^t \text{ can produce } y^t\}. \tag{3}$$

The technology described by the production possibility set L^t satisfies the usual set of axioms: closedness, nonemptiness, scarcity, and no free lunch. The frontier of the production possibility set for a given output vector is defined as the input vector that cannot be decreased by a uniform factor without leaving the set.

The nonparametric distance functions can be defined in either the envelope form or a dual equivalent approach that can be derived from the envelope or primal form (see Kuosmanen, Post, and Sipiläinen 2004). The envelope approach is normally the one preferred in the literature to estimate distances. On the other hand, the dual form has the advantage of a more intuitive specification, offering an economic interpretation of the problem. It also allows an explicit estimation of input and output shadow prices and the possibility of imposing bounds to those prices. Hence we focus here on the dual form for this study.

The dual linear program measures efficiency as the ratio of a normalized weighted sum of all outputs. The weights are obtained by solving the following equation (Coelli and Prasada Rao 2001):

$$\begin{aligned}
&\max_{\rho,\omega} \sum_{k=1}^{m} \rho_k y_{ik} \\
&s.t. \\
&\sum_{j=1}^{n} \omega_j x_{ij} = 1 \\
&\sum_{k=1}^{m} \rho_k y_{ik} \underset{i}{-} \sum_{j=1}^{n} \omega_j x_{ij} \le 0 \qquad \mathrm{i} = 1,\ldots,\mathrm{r} \\
&\rho_k, \omega_j \ge 0 \qquad\qquad \mathrm{k} = 1,\ldots,\mathrm{m};\ \mathrm{j} = 1,\ldots,\mathrm{n}\ ,
\end{aligned} \tag{4}$$

where the optimal weights ρ_k and ω_j are respectively output *k* and input *j* shadow prices.

Kuosmanen, Post, and Sipiläinen (2004) generalize the dual interpretation of the distance function to the case of closed, nonempty production sets satisfying scarcity and no free lunch, showing that the distance has the following dual formulation:

$$D_0^t(x^t, y^t) = \max\left\{\frac{\rho y^t}{\omega x^t} : \frac{\rho y^t}{\omega x^t} \le 1 \forall (y^t, x^t) \in L^t\right\}. \tag{5}$$

They interpret this distance function as “the return to the dollar,[2] at the ‘most favorable’ prices, subject to a normalizing condition that no feasible input-output vector yields a return to the dollar higher than unity at those prices” (2004, pp 99_). There exists a vector of shadow prices for any arbitrary input–output vector; however, these prices need not be unique. Kuosmanen, Post, and Sipiläinen (2004) define the set of shadow price vectors as

$$V^t(y^t, x^t) = \left\{(\rho, \omega) \in R_+^{n+m} : \frac{\rho y}{\omega x} = D^t(y, x); \frac{\rho y^t}{\omega x^t} \le 1 \forall (y^t, x^t) \in L^t\right\} \tag{6}$$

and contend, in the spirit of the theory of revealed preferences (Varian 1984), that “the observed allocation of inputs and outputs can indirectly reveal the economic prices underlying the production decision” (2004, _pp 100_). Based on this, they assume that decisionmaking units allocate inputs and outputs to maximize return to the dollar. Such prices are well defined and are observed by decisionmakers but are not known by the productivity analyst. Assuming that decisionmaking units allocate inputs and outputs to maximize return to the dollar, Kuosmanen, Post, and Sipiläinen (2004) define the production vector (y^t, x^t) as allocatively efficient with respect to technology L^t and prices (ρ^t, ω^t) if and only if (ρ^t, ω^t) $\in V^t(y^t, x^t)$. Allocative efficiency is a necessary but not sufficient condition for maximization of return to the dollar given that it allows for technical inefficiency (production in the interior of the production possibility set). This dual approach to the problem of efficiency and input allocation will be used below to analyze the plausibility of shadow prices obtained when estimating efficiency and eventually to correct those prices, introducing exogenous information into the linear programming problem.

Introducing Bounds to Shadow Input Shares

The lack of prior price information for inputs was pointed out as the prime motivation for estimating nonparametric Malmquist indexes for the analysis of TFP change in SSA. If we do not constrain the linear programming equation used in DEA to determine efficiency, we allow total flexibility in choosing shadow prices. Because of the lack of price information already mentioned, in most of the literature on efficiency and nonparametric TFP analysis, flexibility has been considered to be one of the major advantages of DEA when comparing it with other techniques used to measure efficiency or productivity (Pedraja-Chaparro, Salinas-Jimenez, and Smith 1997). However, total flexibility for the weights has been criticized on several grounds, given that the weights estimated by DEA can prove to be inconsistent with prior knowledge or accepted views on relative prices or cost shares.

Pedraja-Chaparro, Salinas-Jimenez, and Smith (1997) stressed two main problems with respect to allowing total shadow price flexibility. First, by allowing total flexibility in choosing shadow prices, inputs considered important a priori could be all but ignored in the analysis or could end up being dominated by inputs of secondary importance. Such is the case when linear programming equations assign a zero or close to zero price to some factors because of the particular shape of the production possibility set. Second, the relative importance attached to the different inputs and outputs by each unit

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[2] *Return to the dollar* is an economic criterion to evaluate performance. Introduced by Georgescu-Roegen (1951) and referred to by Kuosmanen, Post, and Sipiläinen (2004), it measures the ability of producers to attain maximum revenue to cost. The assumption of allocative efficiency depends on the specified economic objectives of the firms through the shadow price domain (Kuosmanen, Post, and Sipiläinen 2004).

should differ greatly. Although some degree of flexibility on the weights may be desirable to reflect each decisionmaking unit's particular circumstances, it may often be unacceptable to have weights varying substantially from one decisionmaking unit to another. Another argument used against total flexibility of shadow prices (Kuosmanen, Cherchye, and Sipiläinen 2006) is that in some cases, a certain amount of information regarding the input and output prices or shares might be available. In that case, the analysis can be strengthened by imposing price information in the form of additional constraints that define a feasible range for the relative prices. Therefore, a strong case seems to exist for the analysis of shadow prices obtained from DEA when estimating efficiency and TFP, and eventually for considering the introduction of restrictions on shadow prices or cost shares, setting limits on which prices or shares can vary.

To define suitable limits on the value that input shares take, we set an upper and a lower bound (a_i, b_i) to the input share in equation (4). We define the standard distance function where ρ and ω are, respectively, the output and input shadow prices and where $\omega_i^t \times x_{io}^t$ (the input shadow prices multiplied by the input quantities) is equal to the implicit input shares, as shown in Coelli and Prasada Rao (2001):

$$D^t(y_k^t, x_k^t) = \underset{\rho,\omega}{Max} \sum_{r=1}^{s} \rho_r y_{ro}^t \,,$$

s.t. (7)

$$\sum_{i=1}^{m} \omega_i^t x_{io}^t = 1 \,,$$

$$\sum_{r=1}^{s} \rho_r^t y_{rj}^t - \sum_{i=1}^{m} \omega_i x_{ij}^t \leq 0 \,,$$

$$a_{io}^t \leq \omega_i^t x_{io}^t \leq b_{io}^t \quad \mathrm{i} = 1,\ldots,\mathrm{m} \,,$$

$$\rho, \omega \geq 0 \,.$$

Note that the introduction of bounds on shadow input shares constitutes an additional constraint to the original formulation. Restricted and unrestricted models will provide the same results only if all the additional restrictions imposed are nonbinding. In general, the narrower the imposed bounds, the larger the expected differences between model results.

To define the bounds for the input shares, we introduce information on the likely value of the shares of the different inputs from Evenson and Dias Avila (2007). These authors estimated crop input cost shares for 32 SSA countries by adjusting carefully measured share calculations for India. They calculated cost shares of SSA countries by scaling India's input shares, comparing India's input-to-cropland ratio with the same ratio for the particular SSA country. Given that inputs used in the study by Evenson and Dias Avila (2007) are similar to those used here, we use information from that study to determine the maximum and minimum share values for each input among all countries and use those estimated shares as a rough reference to set the limits between which input shares in DEA estimates for SSA countries can vary. By setting these general limits for all countries, we allow input shares to vary, keeping flexibility and uncertainty about the true value of such shares and contemplating differences in the unique circumstance of each individual country. With the imposition of share bounds, the linear programming equation can no longer disregard the less favorable inputs, and we ensure that the most important outputs and inputs are given higher weights than the ones considered less important. A more thorough discussion of the bounds imposed and a comparison of the results of the constrained and unconstrained equations used in the estimation of distance functions can be found in Nin-Pratt and Yu (2010).

Data and Countries Included in This Study

To estimate TFP growth in SSA, the only internationally comparable database available to us is that of the Food and Agriculture Organization of the United Nations (FAO 2007). It provides national time-series data from 1961 to 2006 for the total quantity of different agricultural inputs and output volumes, measured in international dollars. We use one output (agricultural production) and five inputs (labor, land, fertilizer, tractors, and animal stock) for 98 countries, including 26 SSA countries, to estimate TFP.[3] Agricultural output is expressed as the quantity of agricultural production measured in millions of 1999–2001 international dollars. Agricultural land is measured as the number of hectares of arable and permanent cropland; labor is measured as the total economically active agricultural population; fertilizer is the metric tons of nitrogen, potash, and phosphates used, measured in nutrient-equivalent terms; livestock is the total number of animals (cattle, buffalo, sheep, goats, pigs, and laying hens) measured in cow equivalents.

Output growth in SSA from 1964 to 1983 was on average 1.80 percent, with the worst performance occurring between 1972 and 1983, when it was below the rate of increase in the use of inputs in agriculture (1.2 percent). The recovery of SSA's agriculture resulted in output growth rates of 3.2 percent per annum between 1984 and 2003, slightly surpassing the population growth rate of 2.6 percent over the same period. However, despite the recent recovery, output per capita in 2003 was only close to its level in the 1960s.

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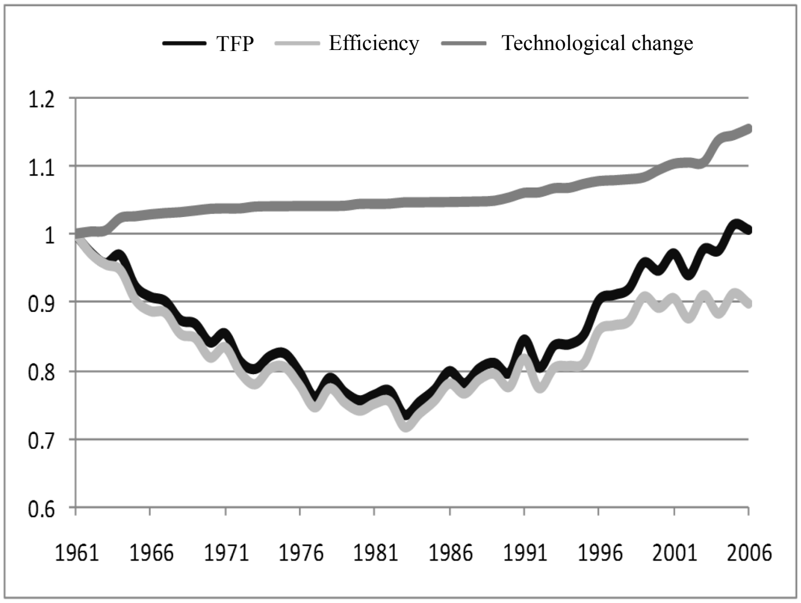
[3] We combine a dissimilarity index developed by Fox, Hill, and Diewert (2004) and a modification to the DEA model suggested by Andersen and Petersen (1993) to identify outliers. The dissimilarity index provides bilateral comparisons of the input–output vector of all countries with a reference input–output vector defined as the mean of all countries, showing how different each country is from the mean. The method by Andersen and Petersen (1993) measures the influence that some observations have on efficiency estimates of other observations.

3. AGRICULTURAL TFP GROWTH, 1961–2006

The overall performance of agriculture in SSA was poor between 1961 and 2006. A simple average of TFP measures at the country level for a sample of 26 SSA countries shows that annual growth in that period was almost zero (0.02 percent). This average, however, hides significant variations across time, where two periods with contrasting results can be distinguished (Figure 3.1 and Table 3.1). The first period, characterized by poor performance and negative productivity growth (-1.33 percent per annum), stretches from the mid-1960s to the mid-1980s. Recovery starts in 1984/85 and extends to 2006, with agricultural TFP growing at 1.37 percent per year. More important, the growth has been accelerating: The annual growth rate was 1.25 percent in the period 1984–1995, and it increased to 1.43 percent in the period 1996–2006.

Figure 3.1—Cumulative agricultural TFP growth and decomposition in efficiency and technical change for SSA, simple geometric mean



Source: Authors' estimation.
Note: Index = 1 in 1961.

Table 3.1—TFP growth rate and decomposition for different periods (percentage)

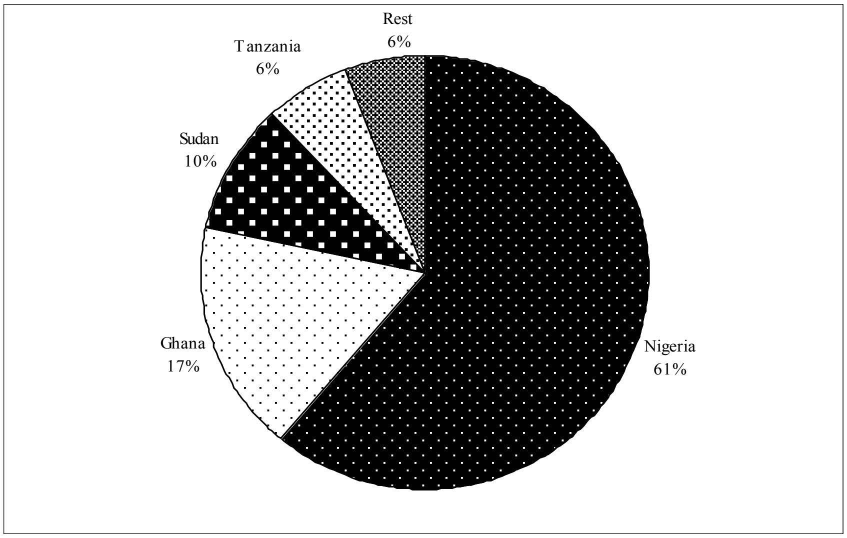
	TFP	Efficiency	Technical change
1961–2006	0.02	-0.24	0.32
1961–1983	-1.33	-1.32	0.20
1984–2006	1.37	0.90	0.45
1984–1995	1.25	1.28	0.25
1996–2006	1.43	0.77	0.65

Source: Authors' estimation.

The decomposition of SSA's TFP growth into efficiency and technical change shows that most TFP growth of the last 20 years is the result of SSA catching up to the technology frontier after falling behind during the period 1970–1983 (Table 3.1). It is clear from the table that between 1984 and 2006 the region was only catching up with efficiency levels of the early 1960s.

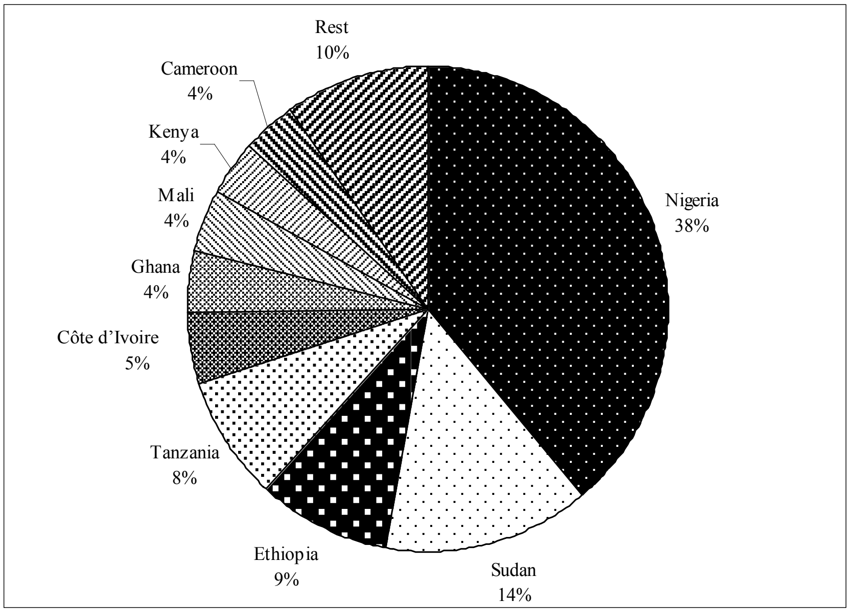
The TFP performance of individual countries varies depending on the period considered. Between 1984 and 1993, two SSA countries explain most of the region's agricultural TFP growth: Nigeria and Ghana, contributing 61 and 17 percent, respectively. Other countries with a relatively significant contribution to TFP growth during that period are Sudan and Tanzania (see Figure 3.2a). Those four countries together explain 94 percent of total TFP growth in our sample over the period of 1984–1993. The number of countries contributing to total TFP growth increases significantly between 1994 and 2006, with nine countries explaining 90 percent of TFP growth during that period. In addition to the four major contributors in the period 1984–1993, Ethiopia, Côte d'Ivoire, Mali, Kenya, and Cameroon also fueled the acceleration of TFP growth in the period 1994–2006 (Figure 3.2b).

Figure 3.2a—Contribution of different countries to TFP growth in SSA, 1984–1993



Source: Authors' estimation.

Figure 3.2b—Contribution of different countries to TFP growth in SSA, 1994–2006



Source: Authors' estimation.

Looking at agricultural TFP growth rates for individual countries between 1984 and 2006, we observe that TFP grew by more than 1.5 percent per annum in 10 of the 26 countries in our sample (Table 3.2). Angola led the group in terms of productivity performance, growing at 4 percent annually (average index of 1.04). Nigeria and Ghana also ranked high in the sample, with growth rates reaching 3.4 and 3.0 percent, respectively. Tanzania and Sierra Leone also showed remarkable growth, with average TFP growth rates topping 2 percent.

Table 3.2—Ranking of countries by TFP growth performance, 1984–2006 and 1995–2006

	1984–2006				1995–2006		
	TFP	Efficiency	Tech. change		TFP	Efficiency	Tech. change
Angola	1.040	1.040	1.000	Angola	1.063	1.063	1.000
Nigeria	1.034	1.034	1.000	Mozambique	1.043	1.043	1.000
Ghana	1.030	1.028	1.002	Tanzania	1.037	1.037	1.000
Tanzania	1.024	1.024	1.000	Burkina Faso	1.034	1.026	1.007
Sierra Leone	1.024	1.017	1.006	Sierra Leone	1.030	1.017	1.012
Togo	1.019	1.014	1.005	Nigeria	1.025	1.025	1.000
Kenya	1.018	1.013	1.005	Ghana	1.021	1.016	1.004
Sudan	1.017	1.017	1.000	Mali	1.021	1.019	1.002
Cameroon	1.016	1.011	1.005	Zambia	1.020	1.019	1.001
Chad	1.016	1.014	1.002	Madagascar	1.018	1.018	1.000
Mali	1.016	1.015	1.001	Ethiopia	1.016	1.015	1.001
Benin	1.016	1.000	1.016	Cameroon	1.014	1.005	1.009
Mozambique	1.014	1.014	1.000	Guinea	1.014	1.014	1.000
Burkina Faso	1.013	1.010	1.004	Zimbabwe	1.011	0.987	1.024
Zambia	1.013	1.013	1.000	Togo	1.010	1.004	1.006
Gabon	1.013	1.013	1.000	Kenya	1.010	1.001	1.009
Malawi	1.013	1.009	1.003	Côte d'Ivoire	1.009	1.002	1.007
Ethiopia	1.010	1.010	1.001	Gabon	1.009	1.009	1.000
Côte d'Ivoire	1.009	1.006	1.004	Malawi	1.008	1.001	1.007
Madagascar	1.004	1.004	1.000	Sudan	1.007	1.007	1.000
Guinea-Bissau	1.004	1.003	1.001	Guinea-Bissau	1.002	1.001	1.001
Zimbabwe	1.000	0.985	1.015	Benin	1.001	0.986	1.015
Senegal	1.000	0.996	1.004	Gambia	1.000	1.000	1.000
Guinea	0.999	0.999	1.000	Swaziland	0.999	0.942	1.061
Swaziland	0.993	0.957	1.037	Chad	0.998	0.994	1.004
Gambia	0.989	0.989	1.000	Senegal	0.977	0.970	1.006

Source: Authors' estimation.
Notes: Index = 1 means zero growth. TFP = efficiency*technical change.

This ranking changes if we focus on the most recent years, between 1995 and 2006. As shown in the last three columns of Table 3.2, Angola was still the country with the fastest growing agricultural TFP, but Mozambique, Tanzania, and Burkina Faso rose in influence, with impressive growth in the agricultural sector. Nigeria and Ghana were still among the best SSA performers, although their average

TFP growth slowed slightly in the 1995–2006 period. Mali, Zambia, Madagascar, and Ethiopia also improved their performance significantly during this period.

Decomposition of TFP growth into its components in Table 3.2 shows that in general, most of TFP growth is explained by efficiency gains, which corresponds to the fact that most countries are recovering from periods of negative productivity growth and reduction in efficiency. For instance, fast TFP growth in Angola was the result of catching up after an extended period of civil war, which is reflected in the zero growth rate of technical change (index = 1). Likewise, TFP growth in Nigeria and Ghana was also mainly explained by efficiency growth instead of technology advances. In the case of other countries in coastal West Africa, only Benin shows technical change making a significant contribution to TFP growth. A similar result is obtained in East Africa. In southern Africa, the contribution of technical change to TFP appears to have been important in the case of Swaziland and Zimbabwe, but the performance of agriculture in these countries was generally poor due to growing inefficiency.

To better understand TFP, we examined partial productivity measures, namely labor and land productivity. These two indicators capture changes in the labor-to-land ratio, which is affected by increased rural population (or agricultural labor force) and the incorporation of arable land in crop production. Rural living standards will deteriorate if the rural population grows faster than yields (Block 1995). Table 3.3 lists the top nine performers in TFP growth in SSA during the period of improved performance, 1995–2006. These countries show on average high TFP growth, slow or negative growth of workers per hectare (with the exception of Angola), and increased labor and land productivity. They are more likely to have experienced increased rural living standards through increased labor income in agriculture. A caveat to these results is that in many of these countries labor per hectare increased slowly because of the incorporation of more land into crop production, given that the rural population was still showing significant growth. If the availability of land decreases in the coming years, yields will need to increase faster to compensate for growth in rural population and to improve rural income.

Table 3.3—Annual changes in labor-to-land ratios, land and labor productivity, and TFP (percentage) in best-performing countries, 1995–2006

	Labor/land	Land productivity	Labor productivity	TFP
Angola	1.82	4.50	2.63	6.35
Nigeria	-0.65	1.47	2.14	2.47
Ghana	-0.61	1.46	2.09	2.06
Mozambique	0.11	1.94	1.83	4.32
Guinea	-0.97	0.71	1.69	1.43
Cameroon	0.50	2.02	1.51	1.43
Mali	0.38	1.70	1.32	2.05
Zambia	0.58	1.76	1.17	1.98
Ethiopia	-0.73	0.42	1.16	1.64

Source: Authors’ estimation.

4. POLICY CHANGES AND GROWTH IN AGRICULTURE

According to Anderson and Masters (2008), most African countries gained independence in the 1960s, a time when central planning was widely seen as a promising strategy for economic development. In this environment, elected governments across Africa typically kept the marketing boards and other instruments for intervention that had been developed by previous administrations, expanding their mandate and increasing public employment, in many cases as a means for electoral politics. In the 1970s, growing fiscal deficits, current account imbalances, and overvalued exchange rates were supported by project aid and loans at a time of zero or negative real interest rates, as governments chose to ration credit and foreign exchange rather than expand the money supply. The result of growing government intervention was political instability and weak market institutions.

African governments faced mounting pressures for public-sector reform with the rise in world real interest rates, combined with a global recession that worsened Africa's terms of trade during the 1980s. These changes made it increasingly difficult for governments to finance the growing fiscal deficits associated with intervention. The World Bank, International Monetary Fund (IMF), and United States Agency for International Development (USAID), as lenders of last resort, made their aid conditional on devaluation, deregulation, privatization, and retrenchment. As a result, trade policy reforms in the 1980s and 1990s were heavily influenced by structural adjustment programs sponsored by the World Bank and IMF. Loan conditions were often blamed for the economic stresses that accompanied them, but the actual implementation of reforms was typically slow and often subject to reversal or offsetting policy changes (Anderson and Masters 2008).

As Anderson and Masters (2008) conclude, Africa's larger countries have had relatively interventionist governments, followed by reform and a degree of recovery. Although the differences in the process of policy reform followed by these countries are frequently emphasized, there are also clear patterns across countries and clear trends in policy choices.

In order to "assess how much policy reform has taken place in Africa, how successful it has been, and how much more remained to be done," the World Bank (1994, _pp xi_) concluded that progress had been made but reforms remained incomplete. It also stressed that poor macroeconomic and sectoral policies were the main factors behind the poor performance of SSA's economy between the mid-1960s and the 1980s. These poorly designed policies resulted in overvalued exchange rates, prolonged budget deficits, protectionist trade policies, and government monopolies, which reduced competition, affected productivity negatively, and imposed heavy taxation on agricultural exports. Food markets were controlled by state enterprises, which also monopolized the import and distribution of fertilizers and other inputs, which were often supplied to farmers at subsidized prices and on credit. The prices farmers received were generally low because of taxation or high costs incurred by state enterprises. The negative impact of such policies on agricultural prices was particularly significant in the case of export crops. During this period, African governments followed a development strategy that prioritized industrialization, with a clear bias against agriculture (Kherallah et al. 2000).

As Kherallah et al. (2000) emphasized, one of the most fundamental shifts in the development strategy for Africa was to view agriculture not as a backward sector but as the engine of growth, an important source of export revenues and the primary means to reduce poverty. The idea behind the structural adjustment programs was that reducing or eliminating state control over marketing would promote private-sector activity and that fostering competitive markets would lead to increased agricultural production.[4]

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[4] The reforms included four types of measures as summarized by Kherallah et al. (2000): (a) liberalizing input and output prices by eliminating subsidies on agricultural inputs and bringing domestic crop prices in line with world prices, (b) reducing overvalued exchange rates, (c) encouraging private-sector activity by removing regulatory controls in input and output markets, and (d) restructuring public enterprises and restricting marketing boards to activities such as providing market information.

Policy reforms have been uneven across sectors and across countries, and occurred in two major waves. The first wave of reforms started in 1984/85. Almost two-thirds of African countries managed to put better macroeconomic and agricultural policies in place by the end of the 1980s. Improvements in the macroeconomic framework also enabled countries to adopt more market-based systems of foreign exchange allocation and fewer administrative controls over imports (World Bank 1994). The second wave of reforms came when many countries made major gains in macroeconomic stabilization, particularly since 1994. The devaluation of the central African franc (CFA franc) significantly improved the performance of the economy and of the agricultural sector in several West African countries. According to the World Bank (2000), by the end of the 1990s, the combination of sustained reforms and financial assistance was associated with better economic performance, at least at the aggregate level. Most prices had been decontrolled and marketing boards eliminated (except in some countries for key exports such as cotton and cocoa). Current account convertibility had been achieved; trade taxes had been rationalized from high average levels of 30 to 40 percent to trade-weighted average tariffs of 15 percent or less. Trade-weighted tariffs are now below 10 percent in more open countries such as Uganda and Zambia. Arbitrary exemptions, although still numerous, have also been rationalized.

In the case of agricultural reform, most policy changes took place after 1986/87, and significant progress was achieved. Most countries lowered export taxes, raised administered producer prices, reduced marketing costs (usually by deregulation and de-monopolization of export marketing), and depreciated the exchange rate of the domestic currency (Cleaver and Donovan 1995). According to the World Bank (2008), the average net taxation of agriculture in SSA was more than halved between the periods 1980–1984 and 2000–2004. During the same period, agriculture-based countries (mostly African countries) lowered protection of agricultural importables, from a 14 percent tariff equivalent to 10 percent, and reduced taxation of exportables, from 45 percent to 19 percent. Most of the decline in taxation was the result of improved macroeconomic policies (World Bank 2008).

As a result of these changes in the first years of the reform, two-thirds of the adjusting countries were taxing their farmers less, and policy changes increased real producer prices for agricultural exporters. Most of the governments that had major restrictions on the private purchase, distribution, and sale of major food crops before adjustment withdrew from marketing almost completely. On the other hand, governments sold only a small share of their assets, although governments have stopped expanding their public enterprise sectors (World Bank 1994).

Market reforms were more comprehensive in food markets than in export crop or input markets. Kherallah et al. (2000) explained progress in food market reforms by the losses that those markets brought to governments, whereas in contrast, the purchase and sale of export commodities brought considerable revenue to many governments. Also, major restrictions on the purchase and sale of agricultural commodities were eliminated: by Benin for tubers; by Ethiopia for teff, maize, and wheat; by Mali for millet and sorghum; by Tanzania for maize; and by Malawi and Zambia partially for maize (Kherallah et al. 2000).

Anderson and Masters (2008) estimated nominal and relative rates of assistance (NRA and RRA respectively) to measure the effect of government policies on returns to farmers in SSA.[5] We highlight here some of their main conclusions from the analysis of changes in rates of assistance to agriculture:

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[5] NRA is defined as the percentage by which government policies raise gross returns to farmers above what they would be without the government's intervention, and are based on estimates of assistance to individual industries at the farmgate. Because farmers are affected not only by the prices of their own outputs but also by the incentives nonagricultural producers face, which affect mobile resources engaged in other sectors, Anderson and Masters (2008) also estimated NRAs for the nonfarm sector to capture the effect that policies had on agriculture through their effect on nonfarm activities. RRAs were then calculated as the ratio of farm and nonfarm NRAs. See Anderson and Masters (2008) for details on these estimates.

- At present, African governments have removed much of their earlier anti-farm and anti-trade policy biases, and most of these changes have come from reduced taxation of farm exports.
- Substantial distortions remain and still impose a large tax burden on Africa's poor. In constant 2000 U.S. dollar terms, the transfers paid by farmers have been reduced to an average of $41 per person working in agriculture, from a peak value of $134 in the late 1970s. However, this lower amount is still appreciably larger than in other regions, given that in both Asia and Latin America, the average agricultural NRAs and RRAs had reached zero by the early 2000s.
- Trade restrictions continue to be Africa's most important instruments of agricultural intervention. Domestic taxes and subsidies on farm inputs and outputs, and non-product-specific assistance, are a small share of total distortions to farmer incentives in Africa. As a result, policy incidence on consumers tends to mirror the incidence on producers, with fiscal expenditures playing a much smaller role than in more affluent regions.

5. LINKING POLICY REFORMS WITH TFP GROWTH IN AGRICULTURE

Since the implementation of structural adjustment programs, policymakers and academics have argued about the causes of and solutions to the African crisis, and the impact of the structural adjustment promoted by international financial institutions in the 1980s and 1990s (see, for example, Arndt, Tarp Jensen, and Tarp 2000; Boratav 2001; Mkandawire 2005). As discussed above, agricultural productivity in SSA was affected by distortions to agricultural incentives through macroeconomic policy, sectoral policy, and trade measures. Importantly, the total effect of distortions on the agricultural sector depends not only on direct agricultural policy measures but also on policy measures altering incentives in nonagricultural sectors. It is therefore important to link a comprehensive package of government assistance with producers' performance.

We use some broad indicators to capture policies that could potentially affect agricultural productivity. We group these indicators into four major categories. The first set of indicators captures macroeconomic policy: money supply, inflation, real exchange rate, and valuation of local currency. Following Rodrik (2008), in order to allow cross-country comparison, we define the real exchange rate as the exchange rate measured in purchasing power parity (PPP) terms. When the real exchange rate is greater than one, the value of the local currency is lower (or more depreciated) than it is in PPP terms. The real exchange rate is corrected to take into account the Balassa-Samuelson effect: As poor countries grow, the labor productivity of their traded-goods sector will rise, spilling over to wages and prices in producing nontrade goods, and so their price structures should become more like those of developed countries. We obtain the index of undervaluation as the difference between actual and adjusted real exchange rate. If the undervaluation index is above one, the local currency is undervalued.

The second set of indicators is used to describe support to the agricultural sector, and includes nominal protection coefficients (NPC) and NRAs. NPCs measure the ratio between the average price received by producers at the farmgate (including payments per ton of current output), and the border price, measured at the farmgate. An NPC value greater than unity suggests that producers are being protected, while an NPC value below unity means that agricultural producers are being taxed. If producers' share in the border price increases, NPC value increases, suggesting that explicit taxation is decreasing. The NRA is computed (following Anderson and Valenzuela 2008) as the percentage by which government policies have raised gross returns to farmers above what they would be without the government's intervention (or if the government lowered them, if NRA < 0). The higher the NRA value, the larger the price distortion. Average NRA defines the delivered rates of distortion to domestic prices for food and export products from policy interventions. Support to the agricultural sector can also come in the form of investment in agricultural R&D and government spending in agriculture, which are proxied by agricultural R&D per researcher and share of agriculture in total government spending, respectively.

The third set of variables focuses on the terms of trade of the agricultural sector, including real producer price (RPP, calculated as the farmgate price divided by CPI or consumer price index) as well as the price of agricultural products relative to nonagricultural products and price of agricultural products relative to industrial products (expressed as the ratio of agricultural GDP deflators to nonagricultural and industry GDP deflators, respectively). These variables not only inspect the price support to agricultural products but also take into account assistance to producers of nonagricultural tradables.

The last set of variables measures trade openness as the ratio of trade to GDP, and openness of the agricultural sector as the ratio of agricultural trade to agricultural GDP. We calculate dependence on agricultural imports as the ratio of agricultural imports to agricultural GDP and the importance of international markets for agricultural output as the ratio of agricultural exports to agricultural GDP. Table 5.1 summarizes the variables, sources, coverage, and expected impact on TFP.

Table 5.1—Summary of policy variables

Variable	Source	Years	Countries	Expected sign
Dependent variables				
TFP	Authors' calculation	1962–2005	39	
Set 1—Macro policies				
Money supply	World Development Indicators (World Bank 2010)	1970–2005	37	+
Inflation	World Development Indicators (World Bank 2010)	1970–2005	37	-
Real exchange rate	Authors' calculation	1970–2005	37	-
Undervalue of currency	Authors' calculation	1970–2005	37	+
Set 2—Support to agricultural sector				
NPC	Authors' calculation	1970–2005	37	+
NRA	Anderson and Valenzuela (2008)	1962–2005	12	-
Agri. research and development	ASTI (IFPRI 2011a)	1981–2005	26	+
Agri. expenditure share	SPEED (IFPRI 2011b)	1980–2007	12	+
Set 3—Agricultural terms of trade				
RPP	Authors' calculation	1970–2005	37	+
Relative price agri./nonag.	Authors' calculation	1970–2005	28	+
Relative price agri./industry	Authors' calculation	1970–2005	28	+
Set 4—Openness of agricultural trade				
Trade openness (export+import)/GDP	Authors' calculation	1962–2005	37	+
Ag trade openness (ag export+ag import) /agGDP	Authors' calculation	1970–2005	37	+
Dependence of ag import ag import/agGDP	Authors' calculation	1970–2005	37	-
Importance of ag export ag export/agGDP	Authors' calculation	1970–2005	37	+

Source: Authors' calculations are based on World Development Indicators (World Bank 2010).

In order to measure the effect of policy interventions on agricultural TFP, the analytical model of the constrained agricultural TFP growth rate is expressed as a function of policy variables including macroeconomic policy, support to agriculture, agricultural term of trade, and agriculture trade. Since many variables are expressed in indexes, we construct an unbalanced panel dataset of growth rates starting with 1971. Evidence from a panel unit root test indicates that growth rate variables are stationary, suggesting that the series considered as our panel are stationary and our parameter estimates are valid. Although panel vector autoregression does not report any serious endogeneity problem, past literature suggests that ignoring endogenous trade variables could produce biased and inconsistent estimators (Rodriguez and Rodrik 2001). At present, instrumentation with geography is still the most promising way to solve the endogeneity problem (Irwin and Tervio 2002; Noguer and Siscart 2005). This paper will take this approach to address the endogeneity issue.

Following Frankel and Romer (1999), the empirical regression adopts a two-stage approach. In the first stage, we derive an instrument of trade openness by estimating a gravity model of bilateral trade. The gravity model is defined as

$$\begin{aligned}\ln\left(\frac{trade_{ij}}{GDP_i}\right) = {} & \alpha_0 + \alpha_1 lnD_{ij} + \alpha_2 lnN_i + \alpha_3 lnA_i + +\alpha_4 lnN_j + \alpha_5 lnA_j + \alpha_6 L_i + \alpha_7 L_j + \\ & \alpha_8 B_{ij} + \alpha_9 B_{ij} lnD_{ij} + \alpha_{10} B_{ij} lnN_i + \alpha_{11} B_{ij} lnA_i + +\alpha_{12} B_{ij} lnN_j + \\ & \alpha_{13} B_{ij} lnA_j + \alpha_{14} B_{ij} L_i + \alpha_{15} B_{ij} L_j + \alpha_{16} SSA_j + \varepsilon_{ij},\end{aligned} \tag{8}$$

where $ln\left(\frac{\mathrm{trade_{ij}}}{\mathrm{GDP_i}}\right)$ is the share of trade between country *i* and country *j* on country *i*'s GDP, $\mathrm{D_{ij}}$ is the distance between the countries, the trading partners' size is measured in population *N* and area *A*, *L* is a dummy for landlocked countries, *B* is a dummy for a common border between countries *i* and *j*, *SSA* is a dummy indicating that country *j* is also located in SSA, and ε is the error term.

Bilateral trade is calculated as the sum of the value of exports and imports between countries *i* and *j,* and is drawn from the UN Comtrade database (2011). The matrix of geographic distance between the two countries, state of being landlocked or not, land area, and existence of a common border (contiguity) are extracted from the Centre d'Etudes Prospectives et d'Informations Internationals (CEPII) database (2011), as described in Head, Mayer, and Ries (2010). The distance is calculated using the great circle formula between the two countries. GDP and population data come from the World Bank's World Development Indicators database (World Bank 2010). The bilateral trade data cover 161 countries in the period 1962–2005.

The gravity model results are shown in Table 5.2 and are generally consistent with our expectation and results in the gravity model literature. Distance between two countries is negatively associated with bilateral trade. Trade between country *i* and country *j* decreases in country *i*'s population and both countries' area, confirming the inverse relationship between countries' trade share and their sizes. In addition, trade increases in country *j*'s population. Trade could fall by as much as 35 percent if country *i* is landlocked and could drop even more if country *j* is also landlocked. Substantially lower trade volume is reported if the trading partner (country *j*) is located in SSA, but this is not necessarily the case if country *i* is an SSA country. Although the presence of contiguity (common border) does not increase trade, the impacts of other geographic factors on trade are changed since the interaction terms between border and other variables are mostly significant. For instance, distance is no longer a deterrent if two countries share a border. Sharing a common border can facilitate flow of commodities in landlocked countries. The statistical significance is very high for all variables with the exception of some interaction terms, indicating that only a small fraction of country pairs in the sample share a common border (Ferrarini 2010). Similar to those of Frankel and Romer (1999), our panel results verify that geographic variables are one of the major contributors to trade, with an R-square of 0.36.

Table 5.2—Gravity model estimation

	ln(openness)		ln(export share)		ln(import share)	
Variable	coef.	std. error	coef.	std. error	coef.	std. error
lnd	-1.01	0.006***	-0.90	0.006***	-0.89	0.006***
lnn_i	-0.02	0.004***	-0.07	0.004***	-0.10	0.004***
lna_i	-0.19	0.003***	-0.15	0.003***	-0.17	0.003***
lnn_j	0.79	0.003***	0.77	0.004***	0.79	0.004***
lna_j	-0.16	0.003***	-0.16	0.003***	-0.13	0.003***
landlock_i	-0.35	0.014***	-0.23	0.015***	-0.36	0.015***
landlock_j	-1.09	0.014***	-1.08	0.015***	-0.85	0.016***
ssa_i	0.36	0.011***	0.09	0.012***	0.33	0.011***
ssa_j	-1.62	0.011***	-1.48	0.012***	-1.65	0.013***
border	-0.68	0.305**	1.06	0.313***	1.04	0.321***
borderXlnd	0.55	0.041***	0.39	0.042***	0.37	0.043***
borderXlnn_i	-0.23	0.027***	0.00	0.027	-0.28	0.028***
borderXlna_i	-0.03	0.025	-0.12	0.026***	-0.02	0.026

Table 5.2—Continued

	ln(openness)		ln(export share)		ln(import share)	
Variable	coef.	std. error	coef.	std. error	coef.	std. error
borderXlnn_j	-0.09	0.027***	-0.19	0.027***	0.09	0.028***
borderXlna_j	-0.10	0.025***	-0.07	0.025***	-0.17	0.026***
borderXlandlock_i	0.88	0.074***	0.58	0.071***	1.03	0.073***
borderXlandlock_j	0.80	0.073***	0.98	0.071***	0.44	0.073***
borderXssa_i	-0.19	0.129	0.05	0.119	-0.59	0.122***
borderXssa_j	0.36	0.129***	0.10	0.119	0.64	0.123***
Constant	3.22	0.061***	1.25	0.066***	1.19	0.068***
Observations	313,154		287,075		287,731	
R-square	0.359		0.314		0.310	

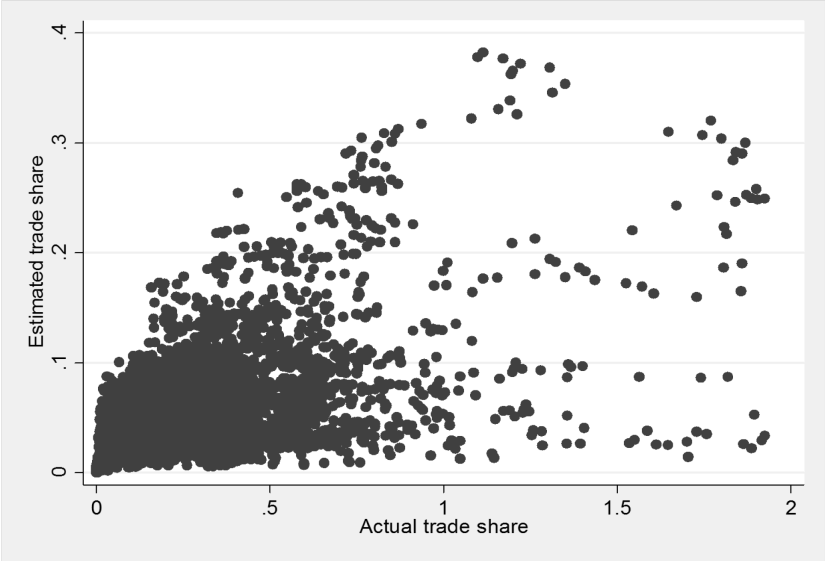
Source: Authors' estimation.
Note: Standard errors *** for p<0.01, ** for p<0.05, * for p<0.1.

Next, the fitted value from the gravity model of bilateral trade is aggregated across trade partners to generate the trade instrument variable (Frankel and Romer 1999). The constructed trade share in GDP of country *i* that is attributable to geographic factors is expressed as

$$\widehat{T}_i = \sum_{j\neq i} \exp[\ln\left(\frac{\mathrm{trade}_{ij}}{\mathrm{GDP}_i}\right)]. \tag{9}$$

The quality of the instrument is evaluated by examining the resemblance of the instrument, estimated trade share $\widehat{T}$, with the actual share *T*. Both Pearson and Spearman correlations yield high correlation coefficients, above 0.5 but slightly lower than the 0.57 reported by Ferrarini (2010). The correlation coefficient is 0.68 when applied to 127 countries in 1985, higher than the correlation of 0.62 found by Frankel and Romer (1999) in 150 countries. Similarly, a visual presentation of the relationship between the estimated and actual ratio proves that a major portion of the variation in overall trade can be explained by the geographic variables (Figure 5.1).

Figure 5.1—Estimated versus actual trade share



Source: Authors' estimation.

Agricultural products are a large part of total trade for many SSA countries. On average, agricultural commodities accounted for 31 percent of export revenue and 21 percent of imports in the period 2000–2005. This ratio reached more than 70 percent in some West African countries like Benin, Burkina Faso, and Guinea-Bissau. Therefore, we also introduce two alternative variables as instruments for exports and imports to reflect the share of agricultural export and import in GDP.

In the second stage of analysis, we regress agricultural TFP on the four sets of policy variables, namely, macroeconomic policy, support to agriculture, agricultural terms of trade, and agricultural trade openness. Since many variables within the same set are highly correlated and have different country and time coverage, we examine different variable combinations for result robustness. Table 5.3 presents the results of panel and instrumental variable (IV) regressions. We expect the coefficient of money supply to be positive because a greater money supply implies more active economic activities and a more productive agricultural sector. Higher inflation increases uncertainty over future relative prices, causes high price volatility, discourages investment and savings, and eventually might lead to slower economic growth. The coefficients of agricultural support are expected to be positive because support should motivate producers to invest, increase the use of inputs, and adopt new technology. The estimated coefficients from the panel fixed effect model are reported in the first column of Table 5.3. The coefficients of money supply and inflation are significant and of the expected sign. Interestingly, we find agricultural sector support and openness of agricultural trade negatively associated with productivity growth.

Table 5.3—Determinants of agricultural TFP, using agricultural trade

		Instrumental variable (IV)				
	Fixed effect	Trade share	Ag trade share	Ag export share	Ag import share	Ag export import share
Money supply	0.01	-0.13	0.01	0.00	0.01	0.01
	(0.005)***	(0.707)	(0.006)	(0.013)	(0.006)**	(0.006)**
Inflation	-0.01	0.15	-0.01	-0.00	-0.01	-0.01
	(0.005)***	(0.782)	(0.007)	(0.014)	(0.006)**	(0.006)**
NPC for agriculture	-0.01	0.14	-0.01	-0.00	-0.01	-0.01
	(0.004)***	(0.724)	(0.006)	(0.013)	(0.006)**	(0.006)**
Relative price ag/nonag	0.01	0.40	0.02	0.03	-0.00	-0.00
	(0.024)	(1.928)	(0.026)	(0.041)	(0.026)	(0.026)
Ag openness	-0.04	0.70	-0.01	0.01	-0.05	-0.05
	(0.010)***	(3.623)	(0.024)	(0.063)	(0.022)**	(0.022)**
Observations	895	851	829	829	829	829
No. of countries	28	28	27	27	27	27
Weak identification		0.0488	184.9	22.36	220.5	110.9

Source: Authors' estimation.
Notes: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

In order to better understand the effect of agricultural trade and the negative sign of agricultural trade openness in Table 5.3, we disaggregate trade into agricultural exports and agricultural imports. The last five columns in Table 5.3 describe the IV estimation results using different instruments for agricultural trade openness. IV analysis does not yield statistically significant results when using the share of trade, agricultural trade, or agricultural export in GDP (columns 2–4 in Table 5.3). However, estimated coefficients based on the share of agricultural import in GDP (columns 5 and 6 in Table 5.3) are almost identical to those of panel fixed effect, which confirms the panel vector autoregression results of no significant endogeneity among agricultural trade openness and other policy variables.

In order to examine the robustness of the trade variable, we replace the trade openness variable used in the regressions reported in Table 5.3 with two separate trade variables: the share of exports and imports in GDP, instrumented with their corresponding predicted values produced in the first stage of gravity model regression. This disaggregation also allows us to pinpoint the relative importance of exports and imports in promoting agricultural productivity. Table 5.4 summarizes the results using these alternative trade indicators. The coefficients of money and inflation under fixed effect models are unchanged from the original trade openness model definition. However, only the coefficients of agricultural imports remain significant despite different instruments. The results echo our finding in Table 5.3, suggesting that growth in agricultural productivity is mainly driven by agricultural imports rather than exports. The negative sign suggests that high dependence on agricultural imports is associated with productivity slowdowns. That is, import of agricultural commodities has a depressing effect on domestic productivity in SSA countries.

Table 5.4—Determinants of agricultural TFP, using agricultural export and import

		IV		IV		IV
	Ag export	Ag export share	Ag import	Ag import share	Ag export & import	Ag export & import share
Money supply	0.01	0.00	0.01	0.01	0.01	0.00
	(0.006)**	(0.008)	(0.005)*	(0.005)	(0.006)*	(0.008)
Inflation	-0.01	-0.00	-0.01	-0.01	-0.01	-0.00
	(0.006)**	(0.008)	(0.004)*	(0.004)	(0.006)*	(0.008)
NPC for agriculture	-0.01	-0.00	-0.01	-0.00	-0.01	-0.00
	(0.005)*	(0.008)	(0.004)*	(0.004)	(0.005)*	(0.008)
Relative price ag/nonag	0.02	0.03	0.01	0.01	0.01	0.01
	(0.024)	(0.025)	(0.024)	(0.024)	(0.024)	(0.025)
Ag exports/ag GDP	-0.02	0.00			-0.01	0.01
	(0.009)*	(0.020)			(0.010)	(0.019)
Ag imports/ag GDP			-0.02	-0.02	-0.02	-0.02
			(0.005)***	(0.007)**	(0.005)***	(0.007)**
Observations	895	829	895	829	895	829
No. of countries	28	27	28	27	28	27
Weak identification		223.5		552.6		104.8

Source: Authors' estimation.
Note: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Instead of supporting policies for the agricultural sector in general, we also zoom in to examine the impact of subsector-specific policies on agricultural TFP. Table 5.5 reports NPC and RPP for three sets of agricultural supporting policies: the whole agriculture sector, agricultural export crops only, and cereals only. Again, the only significant coefficient is for agricultural imports.

When we apply the NRA of cereal and cash crops to a smaller sample of nine countries (not reported in Table 5.5), the beneficial effect of relative price is pronounced and consistent across all model definitions, while improved terms of trade for agricultural commodities lifts agricultural productivity considerably with an elasticity of 0.1.

Table 5.5—Determinants of agricultural TFP, using support to subsectors

	Agriculture		Export crops		Cereal	
	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV
Money supply	0.01	-0.00	0.01	0.00	0.00	0.00
	(0.006)*	(0.008)	(0.005)	(0.005)	(0.005)	(0.005)
Inflation	-0.01	0.00	-0.00	-0.00	-0.00	-0.00
	(0.006)	(0.009)	(0.005)	(0.005)	(0.005)	(0.005)
NPC for agriculture	-0.01	0.00				
	(0.005)	(0.008)				
RPP for agriculture	-0.01	-0.02				
	(0.014)	(0.014)				
NPC for export crops			-0.00	-0.00		
			(0.004)	(0.004)		
RPP for export crops			0.00	-0.00		
			(0.009)	(0.009)		
NPC for cereal					-0.00	-0.00
					(0.004)	(0.004)
RPP for cereal					-0.00	-0.00
					(0.009)	(0.009)
Ag exports/ag GDP	-0.00	0.01	0.01	0.01	0.01	0.01
	(0.009)	(0.019)	(0.007)	(0.012)	(0.007)	(0.012)
Ag imports/ag GDP	-0.03	-0.02	-0.03	-0.02	-0.03	-0.02
	(0.005)***	(0.007)***	(0.005)***	(0.007)**	(0.005)***	(0.007)**
Observations	1107	995	1115	1003	1114	1002
No. of countries	37	36	37	36	37	36
Weak identification		107.0		163.5		157.6

Source: Authors' estimation.
Notes: Agricultural export and import shares are used as instruments.
Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Our last group of agricultural support variables includes agricultural R&D and government expenditure. Agricultural R&D is limited to a smaller sample of 16-18 countries due to data availability. Table 5.6 shows that although the coefficients of agricultural R&D are not significant under model specification, the coefficients of money supply, inflation, sectoral support, and trade openness are all significant and greater than in the large sample. If the sample is further narrowed down to five major agricultural producers (Nigeria, Ghana, Côte d'Ivoire, Sudan, and Kenya), none of the policy variables proves relevant to agricultural productivity (right panel of Table 5.6). Estimation results remain unchanged when relative price between agricultural and nonagricultural products is replaced with RPP to include other important countries like Ethiopia. The results not only further confirm the relationship between agricultural productivity and policies but also highlight the robustness of the relationship under different definitions of agricultural terms of trade.

Table 5.6—Determinants of agricultural TFP, using agricultural research and development

		IV		IV		IV	Nigeria, Ghana, Côte d'Ivoire, Sudan, Kenya		
	Ag export	Ag export share	Ag import	Ag import share	Ag export & import	Ag export & import share	Ag export	Ag import	Ag export & import
Money supply	0.06	0.03	0.06	0.07	0.07	0.02	0.03	0.03	0.03
	(0.038)	(0.068)	(0.037)*	(0.038)*	(0.037)*	(0.080)	(0.065)	(0.065)	(0.063)
Inflation	-0.07	-0.02	-0.07	-0.08	-0.08	-0.00	-0.04	-0.03	-0.04
	(0.046)	(0.101)	(0.046)	(0.047)*	(0.046)*	(0.119)	(0.062)	(0.059)	(0.060)
NPC for agriculture	-0.09	0.22	-0.03	-0.03	-0.09	0.36	-0.04	-0.03	-0.04
	(0.026)***	(0.404)	(0.011)***	(0.012)**	(0.026)***	(0.507)	(0.086)	(0.024)	(0.084)
Ag research and development stock	0.01	-0.04	0.01	-0.01	0.01	-0.05	-0.08	-0.08	-0.08
	(0.058)	(0.086)	(0.057)	(0.058)	(0.057)	(0.101)	(0.149)	(0.149)	(0.144)
Relative price ag/nonag	0.03	0.01	0.02	0.01	0.03	-0.01	0.03	0.03	0.03
	(0.046)	(0.060)	(0.046)	(0.046)	(0.045)	(0.070)	(0.064)	(0.062)	(0.062)
Ag exports/ag GDP	-0.10	0.25			-0.07	0.43	-0.01		-0.02
	(0.027)***	(0.453)			(0.028)**	(0.575)	(0.080)		(0.081)
Ag imports/ag GDP			-0.05	-0.04	-0.04	-0.04		0.00	0.01
			(0.011)***	(0.016)***	(0.012)***	(0.025)*		(0.027)	(0.027)
Observations	355	326	355	326	355	326	101	101	101
No. of countries	18	16	18	16	18	16	5	5	5
Weak identification		1.633		287.6		0.695			

Source: Authors' estimation.
Note: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5.7 examines the impact of public expenditure in the agricultural sector based on a small sample of eight SSA countries. It reveals the importance of agriculture in government policy agenda (Table 5.7). Parallel to the results above, the small sample results corroborates our findings, showing a positive correlation between improved terms of trade for agricultural products and enhanced TFP performance. Lower TFP scores could be driven by high inflation or lower protection of imports.

Table 5.7—Determinants of agricultural TFP, using share of agricultural expenditure

		IV		IV		IV
	Ag export	Ag export share	Ag import	Ag import share	Ag export & import	Ag export & import share
Money supply	0.02	0.03	0.01	0.01	0.01	0.02
	(0.023)	(0.026)	(0.022)	(0.022)	(0.022)	(0.024)
Inflation	-0.06	-0.01	-0.06	-0.05	-0.05	-0.01
	(0.031)*	(0.054)	(0.030)*	(0.029)*	(0.031)	(0.050)
NPC for agriculture	-0.02	0.06	-0.03	-0.03	-0.02	0.04
	(0.019)	(0.074)	(0.011)***	(0.011)**	(0.018)	(0.068)
Ag expenditure	0.00	0.00	0.00	0.00	0.00	0.00
	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)
Relative price ag/nonag	0.14	0.19	0.10	0.10	0.11	0.14
	(0.048)***	(0.076)**	(0.048)**	(0.048)**	(0.048)**	(0.070)**
Ag exports/ag GDP	0.00	0.12			0.02	0.10
	(0.022)	(0.111)			(0.022)	(0.102)
Ag imports/ag GDP			-0.02	-0.01	-0.02	-0.02
			(0.006)***	(0.007)**	(0.006)***	(0.007)**
Observations	198	158	198	158	198	158
No. of countries	8	8	8	8	8	8
Weak identification		7.117		298.3		3.716

Source: Authors' estimation.

Note: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Instead of using money supply and inflation, Tables 5.8 and 5.9 show regression results using the real exchange rate and the index of currency undervaluation as alternative measures to represent macroeconomic policy, respectively. Trade theory predicts that undervalued currency (low real exchange rate in Table 5.8 and high index of currency undervaluation in Table 5.9) will suggest a depreciation of local currency, which encourages exports and discourages imports. If the real value of local currency decreases and the depreciation is passed back to domestic farmers, productivity should increase. Our results in Tables 5.8 and 5.9 showcase the relationship. The effects of other variables are consistent with those of the previous model using fiscal policies: Higher dependence on import openness appears to dampen productivity, and favorable prices for agricultural products provide considerable incentives for farmers to improve performance. In summary, our two-stage approach shows that geographic factors account for a major part of variation in trade performance. Fiscal policies and exchange rates do have impact on agricultural TFP growth. We find a positive impact of money supply on productivity as well as a detrimental effect of inflation on agricultural TFP. Government policy can also boost TFP through the channel of local currency depreciation. In addition, the impact of trade is mainly channeled through imports of agricultural products, which discourage domestic production. In addition, our results are consistent under different model specifications using various agricultural policy combinations, proving the robustness of our results.

Table 5.8—Determinants of agricultural TFP, using real exchange rate

	Ag openness		RPP		NPC		Ag research and development		Ag expenditure	
	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV
Exchange rate	-0.01	0.01	-0.01	0.03	0.03	0.02	0.06	0.10	-0.07	-0.06
	(0.010)	(0.026)	(0.011)	(0.038)	(0.019)	(0.029)	(0.022)***	(0.092)	(0.030)**	(0.038)
NPC for agriculture	-0.01	0.01	-0.01	0.03			-0.09	-0.26	-0.08	-0.05
	(0.009)	(0.023)	(0.009)	(0.033)			(0.023)***	(0.315)	(0.031)**	(0.066)
Relative price ag/nonag	-0.00	-0.00			0.04	0.03	0.05	0.10	0.11	0.10
	(0.022)	(0.023)			(0.062)	(0.070)	(0.042)	(0.139)	(0.050)**	(0.054)*
Ag exports/ag GDP	-0.00	0.02	-0.00	0.04	-0.05	-0.04	-0.09	-0.30	0.01	0.04
	(0.010)	(0.037)	(0.010)	(0.044)	(0.028)*	(0.059)	(0.027)***	(0.396)	(0.021)	(0.085)
Ag imports/ag GDP	-0.03	-0.02	-0.03	-0.02	-0.01	-0.02	-0.04	-0.02	-0.02	-0.02
	(0.005)***	(0.007)***	(0.005)***	(0.007)***	(0.009)*	(0.010)**	(0.012)***	(0.034)	(0.006)***	(0.008)***
RPP for ag			-0.01	-0.03						
			(0.013)	(0.021)						
NRA for cereal					0.00	-0.00				
					(0.003)	(0.005)				
NRA for cash crops					0.00	0.00				
					(0.008)	(0.008)				
Ag research and development stock							0.01	0.02		
							(0.057)	(0.075)		
Ag expenditure									0.01	0.01
									(0.013)	(0.014)
Observations	944	862	1193	1051	167	146	357	328	200	160
No. of countries	28	27	37	36	6	5	18	16	8	8
Weak identification		30.54		21.89		18.90		0.803		4.527

Source: Authors' estimation.
Note: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Table 5.9—Determinants of agricultural TFP, using currency valuation

	Ag openness		RPP		NPC		Ag research and development		Ag expenditure	
	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV	Fixed effect	IV
Currency valuation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	-0.00
	(0.000)***	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)**	(0.000)	(0.000)	(0.000)
NPC for agriculture	-0.00	0.00	-0.00	-0.00			-0.09	-0.41	-0.02	0.00
	(0.000)	(0.000)	(0.001)*	(0.001)			(0.024)***	(0.500)	(0.014)	(0.025)
Relative price ag/nonag	-0.01	0.00			0.06	0.04	0.05	0.18	0.05	0.05
	(0.021)	(0.023)			(0.061)	(0.065)	(0.043)	(0.233)	(0.043)	(0.046)
Ag exports/ag GDP	-0.00	0.01	0.00	0.01	-0.05	-0.04	-0.09	-0.48	0.02	0.07
	(0.008)	(0.014)	(0.007)	(0.013)	(0.028)*	(0.059)	(0.027)***	(0.622)	(0.023)	(0.066)
Ag imports/ag GDP	-0.03	-0.02	-0.03	-0.02	-0.01	-0.02	-0.04	0.00	-0.02	-0.03
	(0.005)***	(0.007)***	(0.005)***	(0.007)***	(0.009)*	(0.010)**	(0.012)***	(0.054)	(0.006)***	(0.007)***
RPP for ag			-0.02	-0.01						
			(0.010)*	(0.011)						
NRA for cereal					0.00	-0.00				
					(0.003)	(0.005)				
NRA for cash crops					0.00	0.00				
					(0.008)	(0.008)				
Ag research and development stock							0.01	0.05		
							(0.057)	(0.109)		
Ag expenditure									0.01	0.01
									(0.013)	(0.014)
Observations	944	862	1193	1051	167	146	357	328	200	160
No. of countries	28	27	37	36	6	5	18	16	8	8
Weak identification		149.4		173.1		17.90		0.473		10.32

Source: Authors' estimation.

Note: Standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

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6. CONCLUSIONS

In this study we analyze the evolution of SSA's agricultural TFP between 1961 and 2006 looking for evidence of recent changes in growth patterns using an improved nonparametric Malmquist index and its components, efficiency and technical change indexes, for 37 SSA countries. Unlike previous studies using this methodology, we constrain the linear programming problem used to estimate distance functions for the Malmquist index to rule out the possibility of zero input shadow prices. We also look at the contribution of different countries to total TFP growth in SSA and analyze changes in the composition of outputs and inputs. Finally, we estimate an econometric model relating TFP growth to policy interventions in agriculture and trade.

Results of our TFP estimates show a remarkable recovery in the performance of SSA's agriculture starting in the mid-1980s and early 1990s after a long period of poor performance and decline, which is mostly attributable to countries' catching up with the technological frontier. Results of our econometric analysis point to policy changes in SSA countries as one of the major factors determining the agricultural sector's improved performance.

The favorable impact of policy changes shows that policies applied by many SSA countries after independence imposed a heavy burden on agriculture and that the structural adjustment implemented in the region brought a more favorable fiscal and sectoral policy environment for agriculture. This more favorable policy environment resulted in improved allocation efficiency and increased production, a more efficient use of inputs, and as a consequence of those, increased productivity. We also obtain a nonsignificant impact of agricultural R&D investment on TFP, which is likely reflecting the lack of technical progress experienced by SSA's agriculture in recent years and the strong relationship between TFP performance and policy during the analyzed period.

Output growth and changes in the relative use of inputs resulted in a significant increase in output per hectare after several years of little or no growth. Considering TFP growth together with balanced growth in land and labor productivity as indicators of good agricultural performance, we find nine countries (Angola, Nigeria, Ghana, Mozambique, Guinea, Cameroon, Mali, Zambia, and Ethiopia) with relatively high TFP growth and sustained growth in labor and land productivity from 1995 to 2006.

Despite improved agricultural performance between 1985 and 2006, several warning signs still exist, calling for more efforts to sustain TFP growth in the coming years. First, the decomposition of TFP growth into efficiency and technical change shows that most TFP growth in the last 20 years has been the result of SSA catching up to the frontier after falling behind between 1970 and 1984. Without increases in the rate of growth of technical change, TFP growth is expected to slow down in the coming years as countries catch up with efficiency levels at the production frontier. According to our estimates, a slowdown in TFP growth is already apparent in the cases of Nigeria and Ghana, the leaders of the recovery of SSA's agriculture in the mid-1980s. Second, substantial distortions remain that still impose a large tax burden on Africa's poor and are much larger than those in other developing regions, as shown by Anderson and Masters (2008). Third, sustained growth in labor productivity faces the challenge of population growth and related increases in agricultural labor per hectare. In many countries, expansion of labor productivity was possible because those countries were still able to incorporate more land into crop production. If the availability of land shrinks in the coming years, yields will need to increase faster to compensate for growth in rural population and improve rural income.

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