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An Updated Look at the Recovery of Agricultural Productivity in Sub-Saharan Africa

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Notices

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Contents

List of Tables

List of Figures

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ABSTRACT

We analyze the evolution of Sub-Saharan Africa's agricultural total factor productivity (TFP) over the past 40 years, looking for evidence of recent changes in growth patterns using a nonparametric Malmquist index. Our TFP estimates show a remarkable recovery in the performance of Sub-Saharan Africa's agriculture during the 1984–2003 period 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, including an overall net reduction in fertilizer use but increased fertilizer use in most of the best-performing countries. Policy changes African countries conducted between the mid-1980s and the second half of the 1990s together with technological innovations available at that time appear to have played an important role in improving agriculture's performance. As TFP growth in Sub-Saharan Africa is mainly a result of catching up to the frontier, we expect growth to slow in the coming years unless African countries accelerate the incorporation of innovations into the production process and increase the speed of technical change.

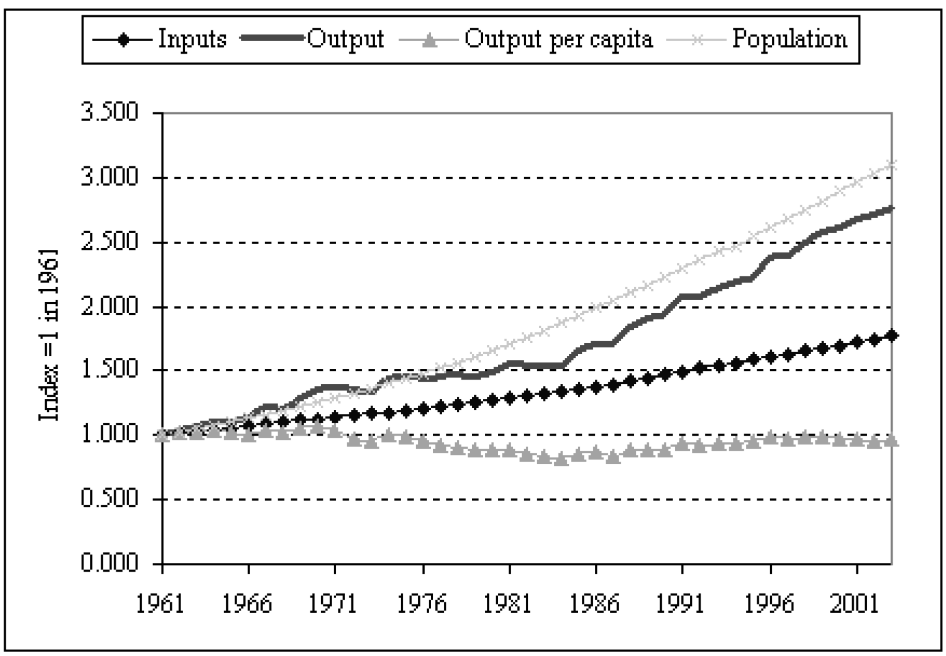
Keywords: agriculture, efficiency, Malmquist index, total factor productivity, technical change, Sub-Saharan Africa

1. INTRODUCTION

In recent years, “an improvement in economic indicators throughout Africa led some observers to argue that the region had finally solved its economic conundrums and could now expect sustained economic growth” (van de Walle 2001). That optimism was 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.

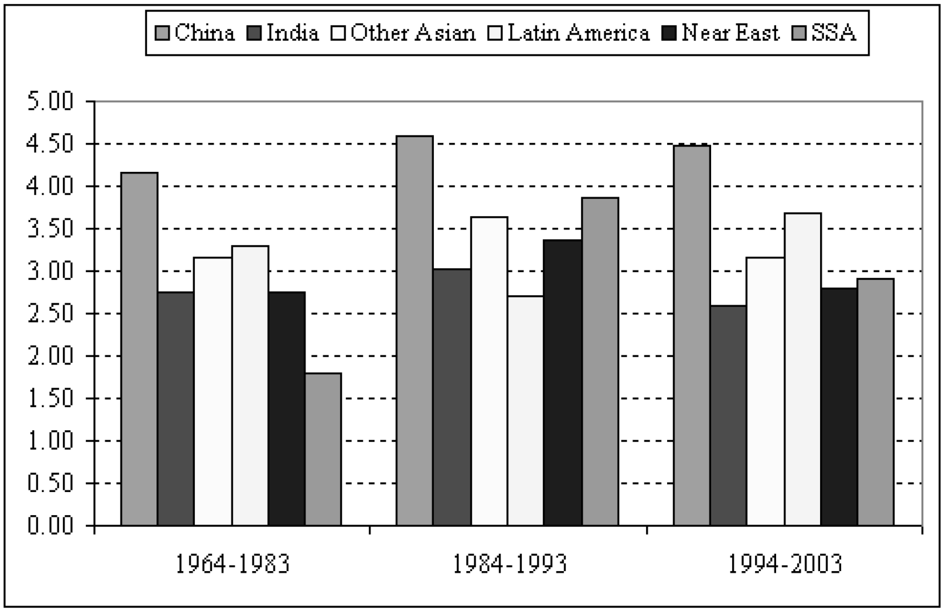
During the 1980s and 1990s, a significant increase in the rate of output growth signaled a change in Sub-Saharan Africa’s (SSA’s) agricultural sector (Figure 1). Output growth in SSA from 1964 to 1983 was on average 1.80 percent, with the worst performance occurring between 1972 and 1983, when output growth was less than 1 percent, below the rate of increase in the use of inputs in agriculture (1.2 percent). The recovery of SSA’s agriculture in the mid-1980s resulted in output growth rates of 3.2 percent per annum from 1984 to 2003. That recovery is also significant when compared with population growth. For the group of Sub-Saharan African countries in this study, population growth was above 2.6 percent per annum from 1964 to 2003. That high rate together with the poor performance of SSA’s agricultural sector resulted in negative growth rates in output per capita until 1985. The trend reverted after 1985, and by 2003, the level of output per capita in SSA was close to its level in the 1960s. The recovery of SSA’s agriculture is also significant when compared with growth in other regions (Figure 2). From 1984 to 1993, agricultural output growth in SSA was below only growth in China, and despite a slowdown, it still compares with growth in other regions in most recent years.

Figure 1. Agricultural output, inputs, and population growth in Sub-Saharan Africa



Source: Estimated by authors using data from FAOSTAT and WDI.
Note: Inputs aggregated using average shares estimated by Evenson and Dias Avila (2007) for Sub-Saharan African countries.

Figure 2. Comparison of agricultural output growth in SSA and other regions in different periods



Source: Estimated by author

Note: Latin America includes Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela. Asia includes Bangladesh, China, India, Indonesia, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam.

Does such growth reflect a structural change in SSA's agricultural sector? What are the factors behind the dynamism agriculture has shown in recent years? Is such growth related to structural adjustment and policy changes that occurred in the past 20 years? Can growth be sustained in the coming years? To answer those questions, it is necessary to analyze the determinants of output growth and establish the contribution of productivity to the improved performance of SSA's agricultural sector. Higher productivity results in a more efficient use of resources because it increases agricultural production while keeping the amount of land and labor used in the production process the same or reducing it. Using resources more efficiently becomes increasingly important as countries begin to face resource constraints, such as reduced arable land. A growing labor force in agriculture together with land constraints could result in diminishing returns to labor and a limited capacity to expand production. Under these circumstances, sustainable agricultural growth can be achieved only through increased total factor productivity (TFP), the amount of output per unit of total factors used in the production process. It is through increased productivity that the agricultural sector can make a substantial contribution to economic growth and development by increasing the welfare of agricultural workers and the rural population, allowing workers to move away from agriculture to more productive sectors, and generating surpluses that can be transferred to other sectors through prices, in particular at early stages of economic development (see, for example, Winters et al. 1998).

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. Studies by Block (1995), Lusigi and Thirtle (1997), and Fulginiti et al. (2004) have shown evidence of agricultural productivity recovery in Africa. Estimates of how *much* productivity has increased vary depending on the study and on the time period analyzed. Since 1985, growth rates in total factor productivity have ranged from 0.5 to 2 percent per year, a clear improvement from growth rates observed in the 1970s and early 1980s. Much of this growth, however, has really been just catching up to previous levels of productivity. Thus, while not enough to put the region on a stable and sustainable growth path, the growth recovery has prompted some optimism in the literature.

Block (1995) found negative growth rates during the 1970s and positive ones during the 1980s. He found that 39 Sub-Saharan African countries grew at approximately 1.6 percent per year from 1983 to 1988. Lusigi and Thirtle (1997) found similar results for 47 African countries. The average growth in productivity was 1.27 percent per year (1961–1991), with no signs of sustained growth in productivity during the 1960s and 1970s. It was only after 1984 that productivity growth picked up. Fulginiti et al. (2004) report total gains of 0.83 percent for 41 Sub-Saharan African countries between 1960 and 1999. However, between 1985 and 1999 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 with the previous studies, Trueblood and Coggins (2003) claim that although selected countries showed signs of recovery in the 1980s, the regional aggregate productivity has declined by an average of 0.9 percent in countries in SSA. Trueblood and Coggins attribute those losses to, among other things, the choice of the technology frontier, which is defined by the most efficient countries in the sample. Whereas Lusigi and Thirtle and others use an average of Sub-Saharan African countries to generate the frontier, Trueblood and Coggins use a global average.

More recently, Coelli and Prasada Rao (2005) estimate TFP for 93 countries, 18 of which are Sub-Saharan African countries. Their results show six African countries with TFP growth above 2 percent during the 1980–2000 period (Burundi, Angola, Nigeria, Ghana, Malawi, and Senegal), but no specific analysis of Africa's growth is performed. Evenson and Dias Avila (2007) estimate the productivity growth of 37 African countries for two periods: 1961–1980 and 1981–2001. They estimate the average TFP growth for Africa (including North Africa) at 1.68 percent from 1981 to 2001, higher than what they find for the 1961–1980 period (1.20 percent). None of these recent studies look specifically at SSA's TFP growth in the 1990s and early 2000.

In an effort to explain the productivity growth, Block (1995) finds that almost two-thirds of TFP growth can be explained by macroeconomic policy changes. Investment in agricultural R&D also made a significant contribution to productivity growth according to both Block (1995) and Lusigi and Thirtle (1997). Fulginiti et al. find that institutional factors such as colonial history and the presence of democracy also contributed to productivity growth.

In addition, researchers have examined whether the source of growth is technical change or purely gains in efficiency. Lusigi and Thirtle (1997) report gains in both technical change and efficiency for the 47 Sub-Saharan African countries studied between 1961 and 1991. They found that only five countries experienced a negative efficiency growth. Slightly over a third of the countries, however, experienced technical regress. Seventy-five percent of the countries with higher labor-to-land ratios experienced higher gains in technical progress than in technical efficiency, while 63 percent of the countries with lower labor/land ratios experienced greater increases in efficiency than in technical change.

This paper contributes to the understanding of the recent changes in SSA's agriculture by analyzing the evolution of the region's agricultural TFP in the past 40 years, looking for evidence of recent changes in growth patterns. To do this we estimate a nonparametric Malmquist index and its components: efficiency and technical change.[1] We make four main contributions. First, we confirm the improved performance of SSA's agriculture since the mid-1980s measured in terms of TFP growth. Second, we look at the performance of individual countries in SSA and determine their contributions to total TFP growth. Third, we analyze changes in the composition of outputs and in the use of inputs to show the contribution of different groups of commodities to total output growth and changes in the use of inputs of best performers. Finally, we use an indicator of policy change, look at production and trade series, and analyze TFP time series for structural changes to find relationships between TFP growth and policy changes in the 1980s and 1990s.

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[1] As in Nin and Yu (2008), we constrain the shadow input shares used in the estimation of distance functions to rule out the possibility of zero input shadow prices.

The paper is organized as follows. The next section presents the methodology employed and the data used to estimate TFP. Section 3 presents productivity estimates and results of analyses. Section 4 discusses policy changes in SSA and tests TFP series for structural changes and relates such changes to policy changes in different countries. 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 use several inputs to produce one or more outputs, and under such circumstances the primary challenge in measuring TFP results from the need to aggregate the different inputs and outputs. The aggregation of inputs and outputs 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) total factor productivity indices; (c) data envelope analysis (DEA); and (d) stochastic frontiers (Coelli et al. 1998).

The Malmquist index, pioneered by Caves, Christensen, and Diewert (1982) and based on distance functions, has become 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 attractive in the context of African agriculture, where usually market prices for the inputs are either nonexistent or insufficiently reported to provide any meaningful information for land, labor, and livestock. In addition, the nonparametric approach can be applied in a multiple-input, multiple-output setting. Also important is 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 (technical 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

$$M_o = \left[M_o^t \times M_o^{t+1}\right]^{1/2} = \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right]^{1/2} . \quad (2.1)$$

This index is estimated as the geometric mean of two Malmquist indices (M_o^t), one using as a reference the technology frontier in *t* (M_o^t), and a second index that uses the frontier in *t + 1* as the reference (M_o^{t+1}). The distance function $D_o^t(x^t, y^t)$ measures the distance of a vector of inputs (*x*) and outputs (*y*) in period *t* to the technological frontier in the same period *t*. On the other hand, $D_o^{t+1}(x^t, y^t)$ 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 applied to the different period-based Malmquist indices. It follows that

$$M_o = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right]^{1/2} . \quad (2.2)$$

The ratio outside the square brackets measures the change in technical efficiency between period t and $t + 1$. The expression inside the brackets measures technical change as the geometric mean of the shift in the technological frontier between t and $t + 1$ evaluated using the frontier at t and at $t + 1$, respectively, as the reference. The efficiency change component of the Malmquist indices measures the change in how far observed production is from maximum potential production between period t and $t + 1$ and the technical change component captures the shift of technology between the two periods. A value of the efficiency change component of the Malmquist index greater than one means that the production unit is closer to the frontier in period $t + 1$ than it was in period t: the production unit is catching up to the frontier. A value 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 the index is less than one. The method has been extensively applied to the international comparison of agricultural productivity. See, for example, Bureau et al. (1995), Fulginiti and Perrin (1997), Lusigi and Thirtle (1997), Prasada Rao and Coelli (1998), Arnade (1998), Fulginiti and Perrin (1999), Chavas (2001), Suhariyanto et al. (2001), Suhariyanto and Thirtle (2001), Trueblood and Coggins (2003), Nin et al. (2003a), Nin et al. (2003b), Nin et al. (2008), and Ludena et al. (2007).

To define the input-based Malmquist index, it is necessary to define and estimate the distance functions, which requires a characterization of the production technology and of production efficiency. We do this in the next section by following Kuosmanen et al. (2004) and formally defining technology and efficiency and relating this measure with allocative efficiency and an economic measure of performance. We choose this approach 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 occurrence of zero shadow prices.

Technology and Distance Functions

We assume, as in Färe et al. (1998), that for each time period $t = 1, ..., T$ the production technology describes the possibilities for the transformation of inputs x^t into outputs y^t, or the set of output vectors **y** that can be produced with input vector **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 (PPS) as follows:

$$\text{Lt} = \{(\text{yt},\text{xt}): \text{such that xt can produce yt}\}. \tag{2.3}$$

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

Two different approaches have been used to define nonparametric distance functions: the envelope form and a dual equivalent approach that can be derived from the envelope or primal form (see Kuosmanen et al. 2004). The envelope approach is normally preferred to estimate distance and efficiency because it requires fewer constraints than the dual form. On the other hand, the dual form has the advantage of a more intuitive specification, offering also 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. We focus here on the dual form.

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

$$\max_{p,w} \sum_{k=1}^{m} p_k y_{ik} \Big/ \sum_{j=1}^{n} w_j x_{ij} \,, \tag{2.4}$$

subject to

$$\sum_{k=1}^{m} p_k y_{ik} \Big/ \sum_{j=1}^{n} w_j x_{ij} \leq 1 \qquad \mathrm{i} = 1,...,\mathrm{r}$$

$$p_k, w_j \geq 0 \qquad \mathrm{k} = 1,...,\mathrm{m};\ \mathrm{j} = 1,...,\mathrm{n},$$

where the optimal weights p_k and w_j are respectively output k and input j shadow prices. Problem (2.4) clearly shows the intuition behind this approach to measure efficiency but cannot be used as such because it has an infinite number of solutions. To solve that problem we normalize the ratio by imposing $\sum_{j=1}^{n} w_j x_{ij} = 1$ (Coelli and Prasada Rao 2001). With this new constraint, the dual problem becomes the following (with p and w different from ρ and ω):

$$\max_{\rho,\omega} \sum_{k=1}^{\mathrm{m}} \rho_{\mathrm{k}} y_{ik}$$

$$s.t.$$

$$\sum_{j=1}^{n} \omega_j x_{ij} = 1$$

$$\sum_{k=1}^{m} \rho_k y_{ik_i} - \sum_{j=1}^{n} \omega_j x_{ij} \leq 0 \qquad \mathrm{i} = 1,...,\mathrm{r}$$

$$\rho_k, \omega_j \geq 0 \qquad \mathrm{k} = 1,...,\mathrm{m};\ \mathrm{j} = 1,...,\mathrm{n} \tag{2.5}$$

Kuosmanen et al. (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:

$$D_0^t(x^t, y^t) = \max\left\{ \frac{\rho y^t}{\omega x^t} : \frac{\rho y^t}{\omega x^t} \leq 1 \forall (y^t, x^t) \in L^t \right\}. \tag{2.6}$$

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." The optimal weights ρ_k and ω_j are respectively output k and input j shadow prices with respect to technology L^t. There exists a vector of shadow prices for any arbitrary input-output vector; however, these prices need not be unique. Kuosmanen et al. (2004) define the set of shadow price vectors as

$$V^t(y^t, x^t) = \left\{ (\rho, \omega) \in R_+^{n+m} : \frac{\rho y}{\omega x} = D^t(y, x); \frac{\rho y^t}{\omega x^t} \leq 1 \forall (y^t, x^t) \in L^t \right\}. \tag{2.7}$$

Kuosmanen et al. (2004) 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." Based on that, they assume that decision-making units allocate inputs and outputs to maximize return to the dollar. Such prices are well defined and are observed by decision

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

makers but are not known by the productivity analyst. Assuming that decision-making units allocate inputs and outputs to maximize return to the dollar, Kuosmanen et al. (2004) define that the production vector (y^t,x^t) is allocatively efficient with respect to technology L 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 PPS). 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 to 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 indices for the analysis of TFP change in SSA. If we do not constrain the linear programming problem 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 et al. 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 et al. (1997) stress 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 because of the particular shape of the PPS, linear programming problems assign a zero or close to zero price to some factors. Second, the relative importance attached to the different inputs and outputs by each unit should differ greatly. Although some degree of flexibility on the weights may be desirable for the decision-making units to reflect their particular circumstances, it may often be unacceptable that the weights should vary substantially from one decision-making unit to another. Another argument used against total flexibility of shadow prices (Kuosmanen et al. 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 between which prices or shares can vary.

To define suitable limits to the value that input shares take, we set an upper and a lower bound (a_i,b_i) to the input share in problem 2.5. We define the standard distance function where ρ and ω are respectively the output and input shadow prices and $\omega_i^t \times x_{io}^t$ (the input shadow prices multiplied by the input quantities) is equal to the implicit input shares as shown in Coelli and Prasada Rao (2001):

$$D^t(y_k^t, x_k^t) = \underset{\rho,\omega}{Max} \sum_{r=1}^{s} \rho_r y_{ro}^t \text{ , s.t.} \tag{2.8}$$

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

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

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

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

Note that the introduction of bounds on shadow input shares constitutes additional constraints 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 the outcomes of each model.

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). In that paper, the authors estimate crop input cost shares for 32 Sub-Saharan African countries by adjusting carefully measured share calculations for India. Cost shares of Sub-Saharan African countries were calculated by scaling India's input shares comparing India's input/cropland ratio to those ratios of the particular Sub-Saharan African country. Given that inputs used in the study by Evenson and Dias Avila 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 Sub-Saharan African 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 circumstances of the individual countries. With the imposition of share bounds, the linear programming program can no longer disregard the less favorable inputs, and we ensure that the most important outputs and inputs are attached 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 problems used in the estimation of distance functions can be found in Appendix A.

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). It provides national time-series data from 1961 to 2003 for the total quantity of different 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 30 Sub-Saharan African countries, to estimate TFP. Initially we included all Sub-Saharan African countries with complete information on output and inputs in the FAOSTAT database. We then checked the database for outliers, and based on that analysis we dropped some of the Sub-Saharan African countries and countries from other regions as well, ending up with 98 countries in our database, of which 30 are Sub-Saharan African.[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

[3] We combine a dissimilarity index developed by Fox et al. (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 measures the influence that some observations have on efficiency estimates of other observations.

animals (cattle, buffalo, sheep, goats, pigs, and laying hens) measured in cow equivalents. Table 1 presents agricultural production indicators of the 30 Sub-Saharan African countries included in this study.

Table 1. Technical indicators of agricultural production in Sub-Saharan African countries included in this study

	Output share %[a]	Workers per 1,000 hectares[b]	Tractors per 1,000 hectares[b]	Animals per 1,000 hectares[b]	Fertilizer kg per hectare[b]	Output ($I) per hectare[b]	Output ($I) per worker[c]
Nigeria	27.0	472	0.9	321	5.8	664	1,405
Sudan	6.6	456	0.7	1,253	4.5	308	676
Ethiopia	6.1	2,204	0.3	1,634	13.2	411	186
Kenya	4.9	2,365	2.5	1,240	28.3	758	321
Ivory Coast	4.7	458	0.6	137	13.0	547	1,193
Ghana	4.5	907	0.6	157	2.6	562	620
Tanzania	4.3	2,880	1.5	1,719	2.7	667	231
Cameroon	3.0	519	0.1	462	5.9	325	627
Madagascar	2.5	1,660	1.0	1,266	2.6	550	332
Mali	2.0	1,708	0.9	1,451	15.0	586	343
Zimbabwe	2.0	1,073	7.2	863	39.4	460	429
Burkina Faso	1.9	1,183	0.4	906	6.4	324	273
Malawi	1.9	1,938	0.6	227	19.9	614	317
Benin	1.7	557	0.1	323	14.8	495	889
Mozambique	1.5	1,789	1.3	174	5.4	265	148
Chad	1.3	767	0.0	865	5.1	288	375
Guinea	1.3	2,043	0.3	911	2.0	592	290
Senegal	1.2	1,286	0.3	751	13.9	368	286
Zambia	0.8	580	1.1	267	9.5	121	210
Togo	0.7	449	0.0	126	7.0	202	449
Mauritania	0.4	1,300	0.8	2,576	5.6	623	479
Sierra Leone	0.35	1,811	0.1	410	0.4	471	260
Gabon	0.3	418	3.0	151	0.6	404	968
Congo, Rep.	0.3	106	1.3	134	7.2	367	348
Swaziland	0.2	630	20.6	1,445	71.7	909	1,444
Mauritius	0.2	56	3.5	467	270.4	1,638	2,931
Guinea-Biss.	0.2	928	0.0	594	1.7	292	314
Botswana	0.2	925	15.8	3,636	12.2	412	445
Gambia	0.1	1,738	0.1	553	2.5	336	193
Lesotho	0.1	835	6.0	981	32.7	290	348
All countries	81.5	1,037	1.0	754	9.0	481	463

Source: Authors, using FAOSTAT data.
[a] Output share in total Sub-Saharan agricultural output.
[b] Land is arable land—used under annual and permanent crops.
[c] Workers are the economically active population in agriculture.

3. TFP GROWTH AND PERFORMANCE OF SUB-SAHARAN AFRICA'S AGRICULTURE, 1964–2003

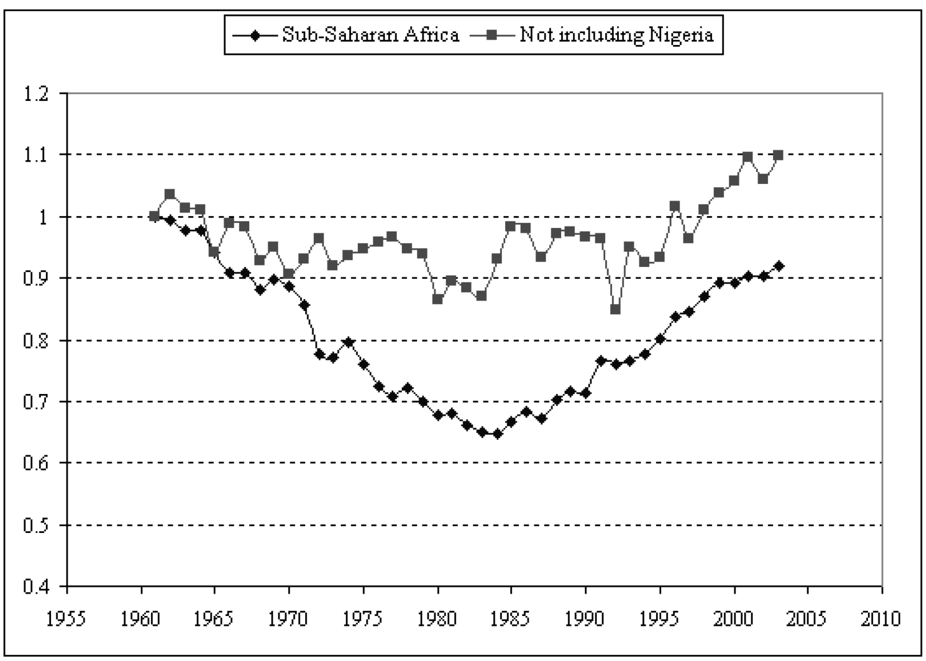
Aggregated Results Using a Weighted Average of 30 Sub-Saharan African Countries

Trends in TFP and TFP decomposition

Agriculture's performance in SSA during the 40-year period from 1964 to 2003 was poor. A weighted average of TFP measures at the country level for a sample of 30 Sub-Saharan African countries shows that annual growth in that period was −0.15 percent. This means that on average, SSA's agricultural TFP was 6 percent lower in 2003 than its level in 1964. Excluding Nigeria from the average TFP estimates, the results are also poor: 0.2 percent growth per annum, or a total TFP growth of 8.4 in 40 years.

That average, however, hides significant variations across time, where two periods with contrasting results can be distinguished (Figure 3). A first period of poor performance and decline stretches from the mid-1960s to the mid-1980s, during which productivity growth in SSA was negative: −2.01 and −0.77 percent per annum if average TFP is estimated respectively including or excluding Nigeria.[4] That period is followed by a period of recovery and improved performance that starts in 1984–1985 and extends up to 2003, the last year for which information is available. During this period, TFP grows at an annual rate of 1.73 percent (1.18 percent excluding Nigeria), with 1.65 percent growth in the first half of the period (1984–1993), compared with −1.67 percent between 1974 and 1983. TFP growth accelerates during the 1990s to 1.83 percent as more countries improve their performance and speed up TFP growth. If we exclude Nigeria, TFP in SSA grows at 1.48 percent per annum from 1994 to 2003, compared with only 0.89 percent between 1984 and 1993.

Figure 3. Index of cumulative TFP growth in SSA (1961 = 1)

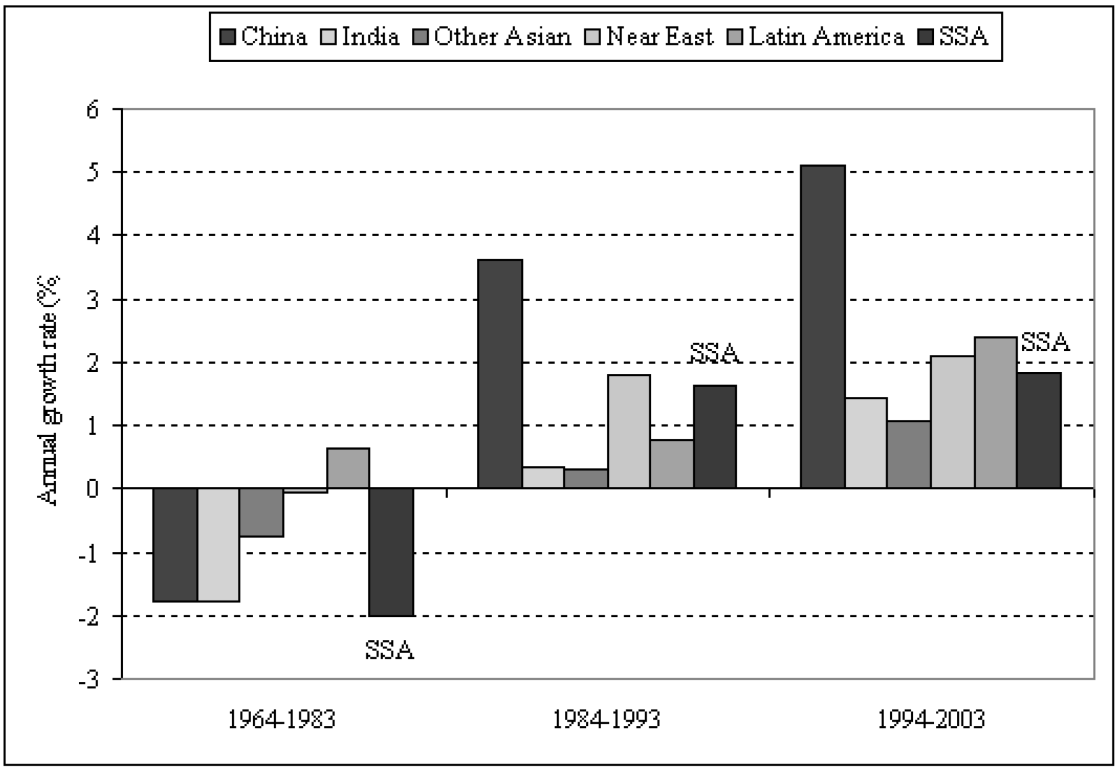


Source: Estimated by authors.

[4] Because of the size of Nigeria's agricultural sector relative to other countries, some of the aggregated results for SSA could be driven by that country. For that reason, some of the results are presented excluding Nigeria.

The improvement in performance of SSA's agricultural sector during the 1984–2003 period is significant not only compared with its past poor performance but also when compared with TFP growth in other regions (Figure 4). Agricultural productivity in SSA clearly fell behind productivity in other regions from 1964 to 1983, even though performance of the agricultural sector in both Asia and Latin America was poor. Between 1984 and 1993, SSA's performance is comparable to that of Near East countries and better than other regions except China. During the 1990s, agricultural TFP growth in SSA was below growth in China but showed growth similar to that in Latin America and the Near East and was above the average growth in a group of Asian countries and India.

Figure 4. Average TFP growth rate of SSA's agriculture in different periods compared with TFP growth in other regions



Source: Estimated by authors.
Note: TFP values for China and India are from Nin Pratt et al. (2007)
Latin America includes Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela. Other Asia includes Bangladesh, Indonesia, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam. Near East includes Algeria, Egypt, Iran, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, and Turkey.

The decomposition of SSA's TFP growth into efficiency and technical change shows that almost all TFP growth of the last 20 years is the result of SSA catching up to the frontier after falling behind during the 1964–1983 period (Table 2). Even though we verified that TFP growth in SSA in 1984–1993 was comparable to that in Asia and Latin America, the composition of that growth differs substantially between regions (Figure 5). Almost all TFP growth during the 1994–2003 period in Other Asian countries, almost half of TFP growth in China, India, and the Near East, and 32 percent of TFP growth in Latin America is explained by technical change, while only 10 percent of total growth in SSA (a mere 0.2 percentage points compared with 2.4 in China, 1.0 percent in Other Asian countries, and 0.77 in Latin America) results from technical change.

Table 2. TFP growth rate and decomposition for different periods (percentage)

	TFP	Efficiency	Technical change
Sub-Saharan Africa			
1964–1973	-2.35	-2.79	0.46
1974–1983	-1.67	-1.70	0.03
1984–1993	1.65	1.59	0.06
1994–2003	1.83	1.63	0.19
1964–1983	-2.01	-2.25	0.25
1984–2003	1.74	1.61	0.12
Sub-Saharan Africa excluding Nigeria			
1964–1973	-0.99	-1.23	0.24
1974–1983	-0.55	-0.58	0.03
1984–1993	0.89	0.77	0.11
1994–2003	1.48	1.16	0.31
1964–1983	-0.77	-0.90	0.14
1984–2003	1.18	0.97	0.21

Source: Estimated by authors.

Figure 5a. Comparison of TFP growth decomposition in SSA and other regions, 1984–1993

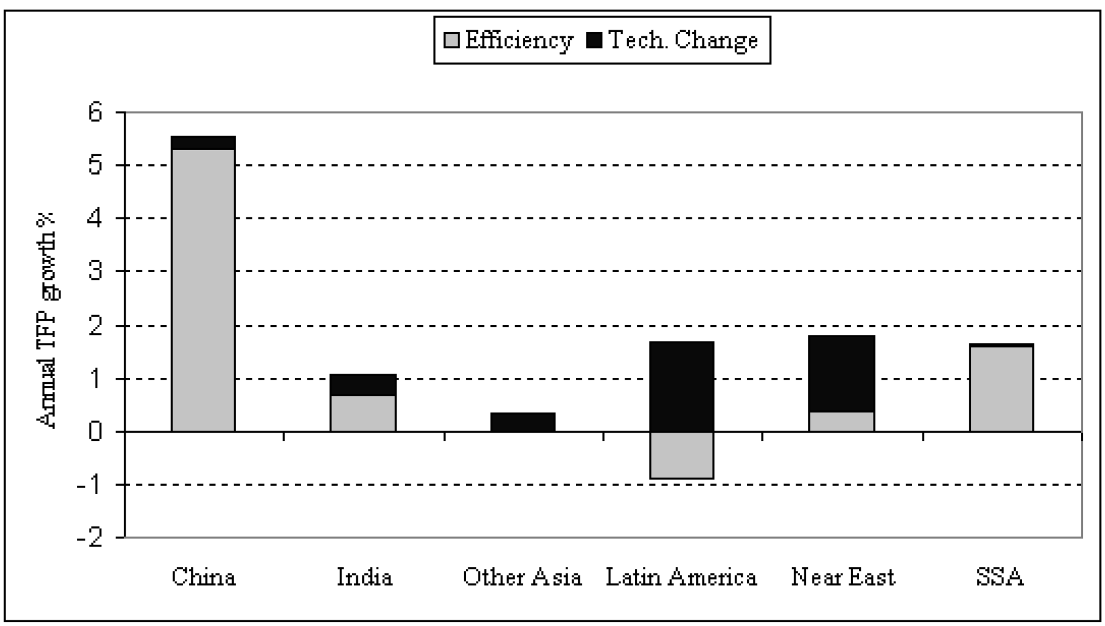
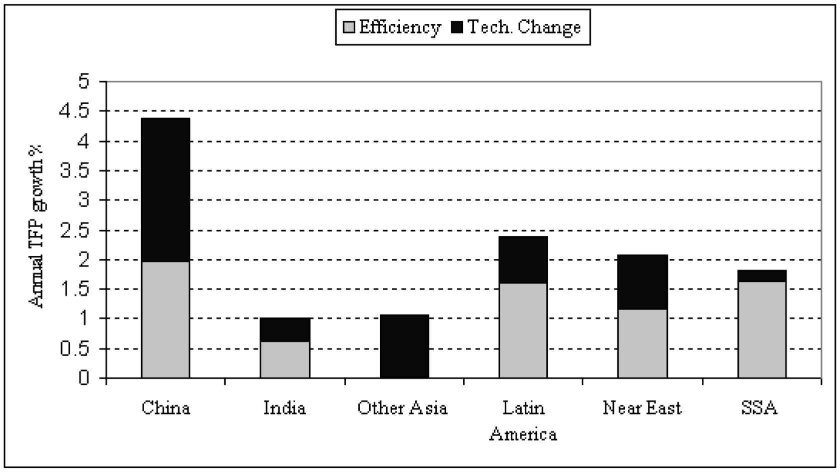


Figure 5b. Comparison of TFP growth decomposition in SSA and other regions, 1994–2003



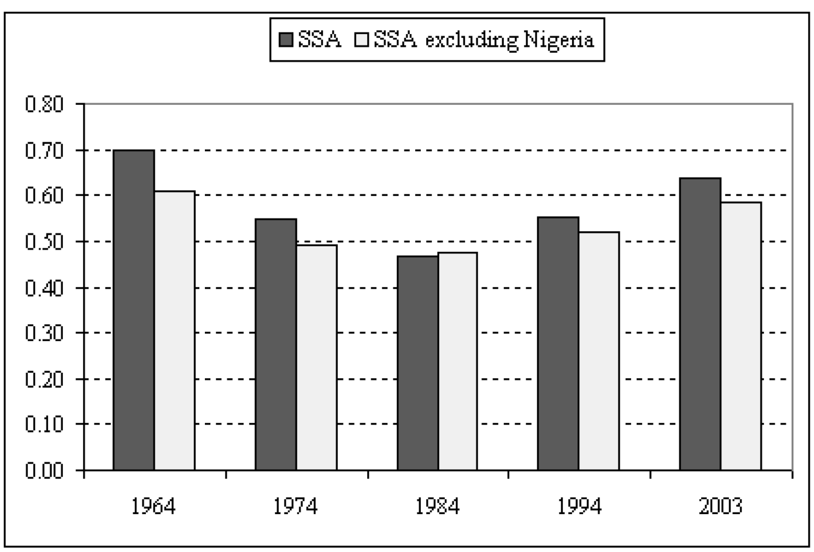
Source: Estimated by authors.

Note: TFP values for China and India are from Nin Pratt et al. (2007).

Latin America includes Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela. Other Asia includes Bangladesh, Indonesia, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, and Vietnam. Near East includes Algeria, Egypt, Iran, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, and Turkey.

Figure 6 shows the level of efficiency of agriculture in SSA relative to efficiency at the technological frontier. It is clear from the figure that during the 20-year period of TFP growth between 1984 and 2003, the region was only catching up with efficiency levels of the early 1960s. This needs to be seen as a warning sign because it means that we should expect TFP growth rates to decrease and converge to the growth rate of technical change as SSA increases efficiency and approaches what are considered average efficiency values of 0.75–1.0 (Wilson 1995). Given the very low growth in technical change shown by SSA's agriculture in the past 20 years, with no changes in the structure of TFP growth, SSA can return to a period of slow TFP growth in the coming years.

Figure 6. Efficiency levels in different periods (efficiency at the frontier = 1)



Source: Estimated by authors.

Changes in Output Structure

Agricultural productivity is affected not only by the level of output of the different crop and livestock activities but also by the composition of outputs. That means changes in the structure of production can alter the overall output/input ratio. Increased efficiency and accelerated output growth in SSA resulted from differential growth between subsectors (Table 3). During the period of accelerated output growth, oil crops, roots and tubers, other cereals, pulses, and milk increased their share while beef, tropical fruits, and traditional export crops reduced their participation in total output. It is important to notice also that maize, which showed growth rates of 3.5 percent from 1984 to 1993, reduced its growth to only 0.9 percent per annum in the 1990s. That slowdown in maize production reduced its share in total output in 2003 almost to the levels shown in 1984. When Nigeria is excluded, we find that chicken meat and other crops (nuts and other fruits) also show high growth rates in recent years.

Table 3. Output growth, composition change, and contribution of different subsectors to growth in SSA's agriculture

	Annual output growth (%)		Share in total output (%)			Change in share (%)		Contribution to total output growth (%)	
	1984–2003	1994–2003	1984	1994	2003	1984–2003	1994–2003	1984–2003	1994–2003
Maize	3.50	0.91	5.39	6.85	5.66	5.03	-17.32	4.86	2.13
Rice	3.36	1.97	4.60	4.68	4.76	3.48	1.76	4.06	2.80
Other cereals	3.37	3.60	9.42	10.47	10.44	10.85	-0.27	8.72	7.57
Export crops	2.85	2.83	13.98	12.54	12.45	-10.94	-0.68	10.08	10.03
Roots & tubers	4.32	3.25	11.06	13.40	13.69	23.77	2.15	15.01	13.28
Pulses	3.10	3.63	3.72	3.70	4.17	12.12	12.59	3.88	4.45
Oil crops	4.61	5.26	6.93	8.10	9.32	34.45	15.02	10.02	12.29
Tropical fruits	2.34	2.10	8.81	7.87	7.38	-16.31	-6.24	5.18	5.12
Vegetables	3.24	3.09	6.71	6.80	6.71	0.07	-1.33	5.96	5.87
Other crops	3.11	3.58	2.95	2.72	2.93	-0.69	7.90	2.51	2.93
Beef	1.29	1.99	14.16	10.61	9.89	-30.11	-6.77	4.13	5.89
Chicken	3.13	3.54	1.98	1.89	1.99	0.46	5.44	1.70	1.75
Shoat meat	2.88	3.54	3.96	3.69	3.78	-4.59	2.40	2.91	3.13
Pig meat	4.96	4.06	0.75	0.88	0.98	30.01	10.83	1.11	1.04
Milk	2.84	2.93	5.57	5.80	5.84	4.82	0.73	5.00	4.94
Animal products	2.19	2.69	26.42	22.87	22.48	-14.91	-1.70	14.86	16.76

Source: Authors, using data from FAOSTAT 2007.

Input use, Input Relationships, and Partial Factor Productivity

Agricultural TFP growth in SSA from 1984 to 2003 can be related from the input side to an adjustment in the relative use of inputs in the production process (Figure 7). The most important change at this level is an absolute reduction in the use of fertilizers. From 1964 to 1983, SSA saw a fast expansion in the use of fertilizers, with growth rates of 8.81 percent on average for 20 years. Growth in fertilizer use falls to 2.62 percent between 1984 and 1993 and becomes negative between 1994 and 2003, a reduction in absolute levels in the use of fertilizer. As is discussed later (see the subsection “Input use, input relationships, and partial factor productivity” under “Results at the Country Level”), most of this reduction in the use of fertilizer is explained by reductions in four countries (with Nigeria explaining 72 percent of the reduction). On the other hand, 21 countries in our sample increased the use of fertilizer during this period. Labor continues to increase faster than other factors, although it appears to be slowing down between 1994 and 2003 compared with previous years.

Figure 7a. Growth rates in the use of inputs in agriculture production (all Sub-Saharan African countries)

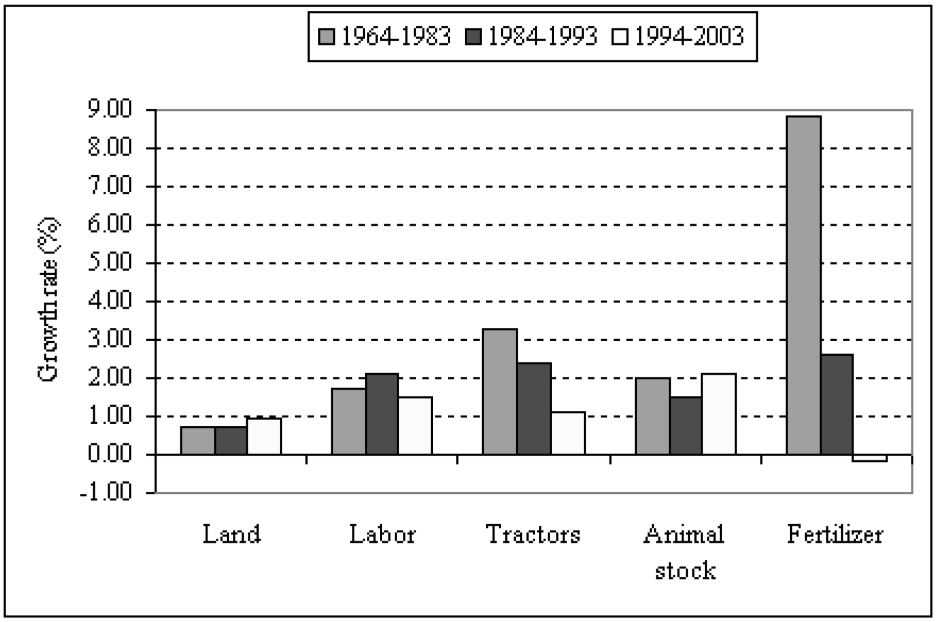
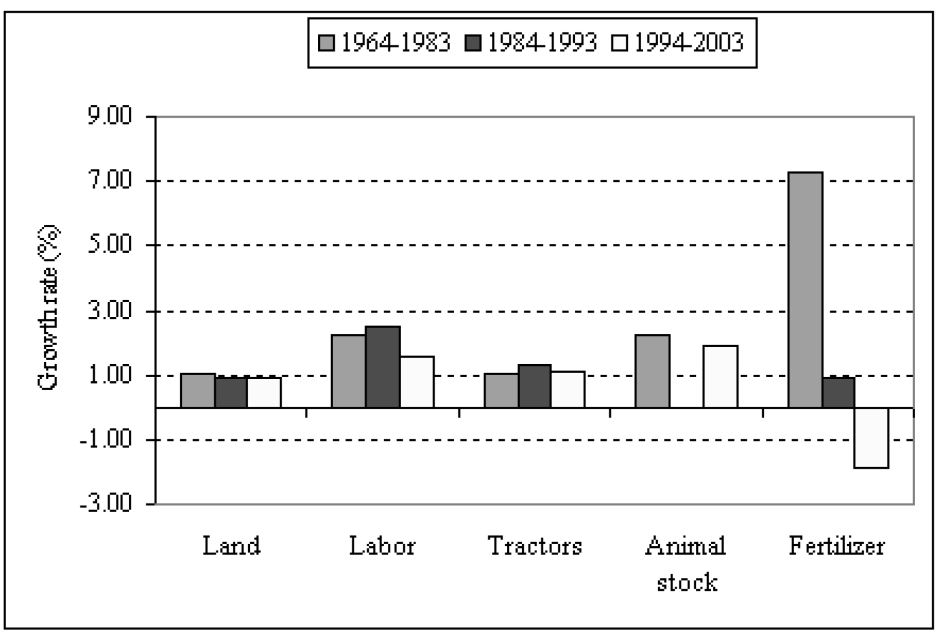


Figure 7b. Growth rates in the use of inputs in agriculture production (excluding Nigeria)



Source: Authors, based on data from FAOSTAT 2007

Relative changes in inputs are shown in Figures 8 and 9 The reduction in the use of fertilizer and increased use of labor and land results in the negative growth of fertilizer use per hectare of arable land and per worker during the 1994–2003 period (Figure 8). The number of workers per hectare of arable land continued to grow, although the growth rate decreased, in the second half of the 1990s. This continuous growth in rural population and labor in agriculture and the slow growth in the number of head of animal stock and the number of tractors resulted in a reduction in the use of capital per worker, while capital per hectare of land remained at levels similar to those at the beginning of the period (Figure 9). The inclusion of Nigeria in the group of Sub-Saharan African countries changes some of these patterns. The main difference is the increase in the number of tractors per hectare and per worker and a slower growth in the number of workers per hectare. Also, the reduction in the use of fertilizer per worker in the 1984–2003 period is much smaller when we include Nigeria.

Figure 8a. SSA: Indices of fertilizer use per hectare and worker (1961 = 1) including all countries

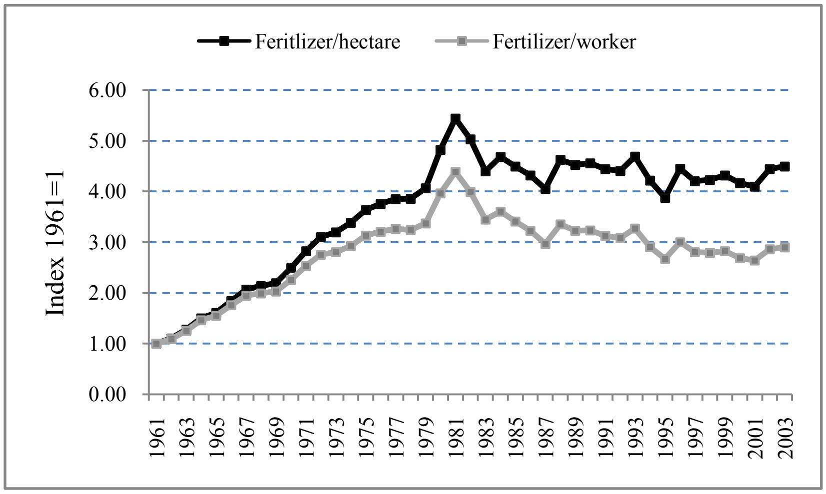
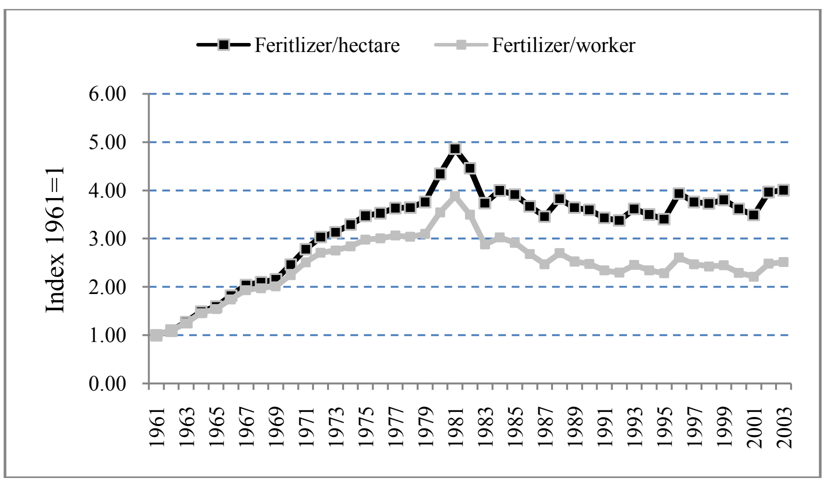


Figure 8b. SSA: Indices of fertilizer use per hectare and worker (1961 = 1) excluding Nigeria



Source: Authors, based on data from FAOSTAT 2007.Despite small changes in the number of animals and tractors per hectare, a decrease in animal stock and tractors per worker, and a reduction in the use of fertilizers, output per hectare increased significantly in the 1984–2003 period after several years of little or no growth (Figure 10). Output per worker also grew during that period, but that growth is more pronounced when Nigeria is included in the group of Sub-Saharan African countries. If Nigeria is not included, there still is evidence of a change in the declining trend of output per worker after 1991: a regression of the log of output per capita against a trend results in an average growth rate of output per capita of 0.5 percent, significant at the 1 percent level.

Figure 9a. SSA: Indices of input use per hectare and worker (1961 = 1) including all countries

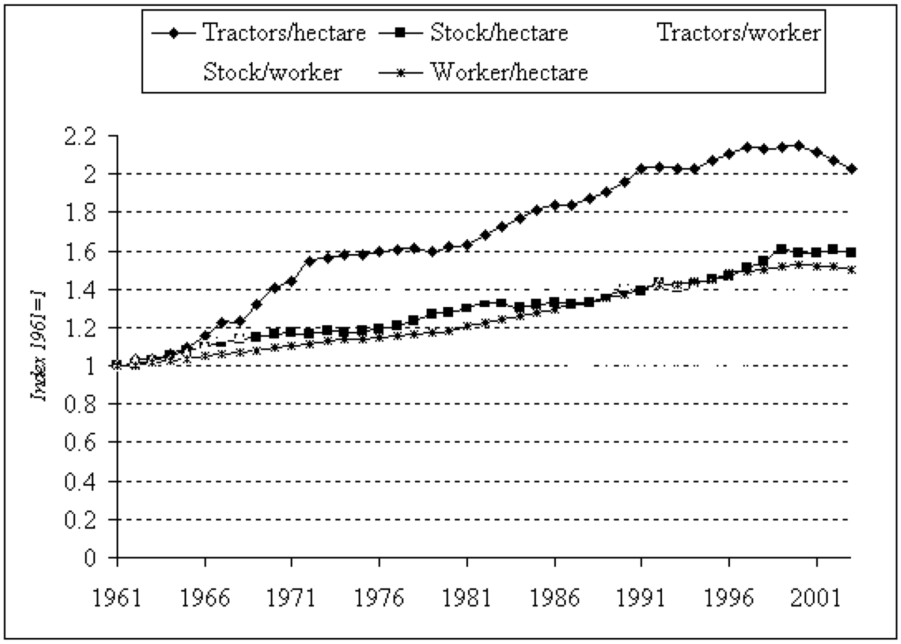
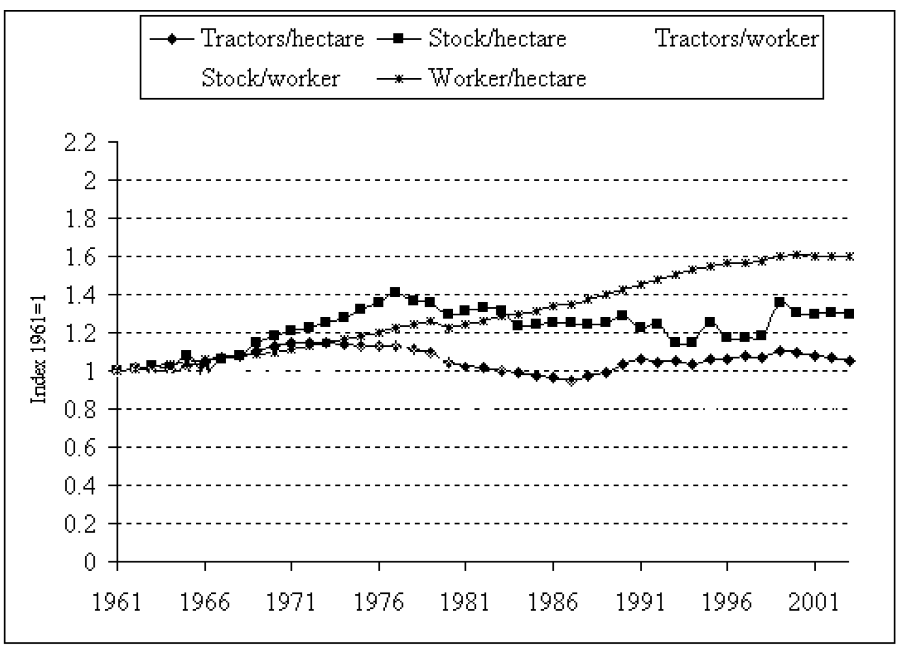


Figure 9b. SSA: Indices of input use per hectare and worker (1961 = 1) excluding Nigeria



Source: Authors, based on data from FAOSTAT 2007.Results at the Country Level[5]

[5] Appendix B presents trends in output, inputs, TFP, efficiency, and technical change for the period 1964–2003 for all countries in our sample.

Figure 10a. Evolution of output per hectare and worker in SSA (I$) including all countries

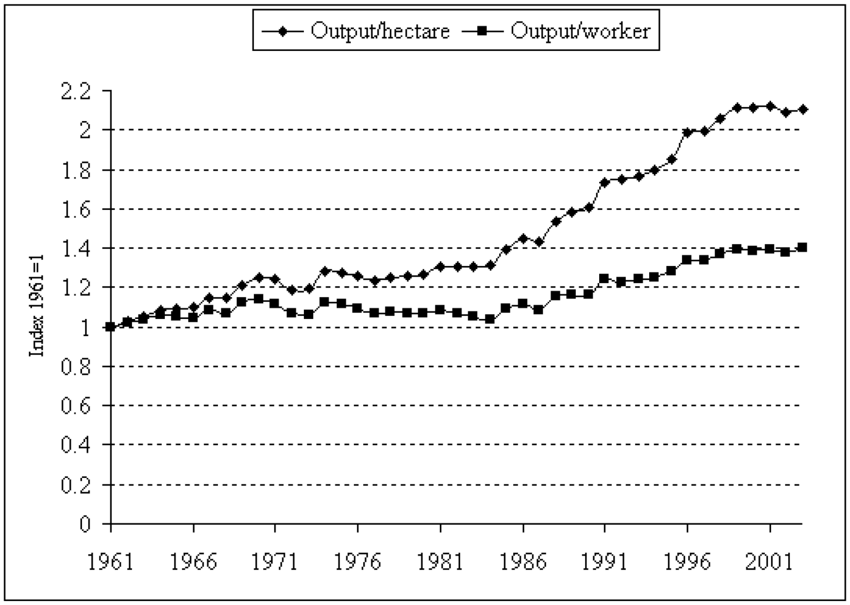
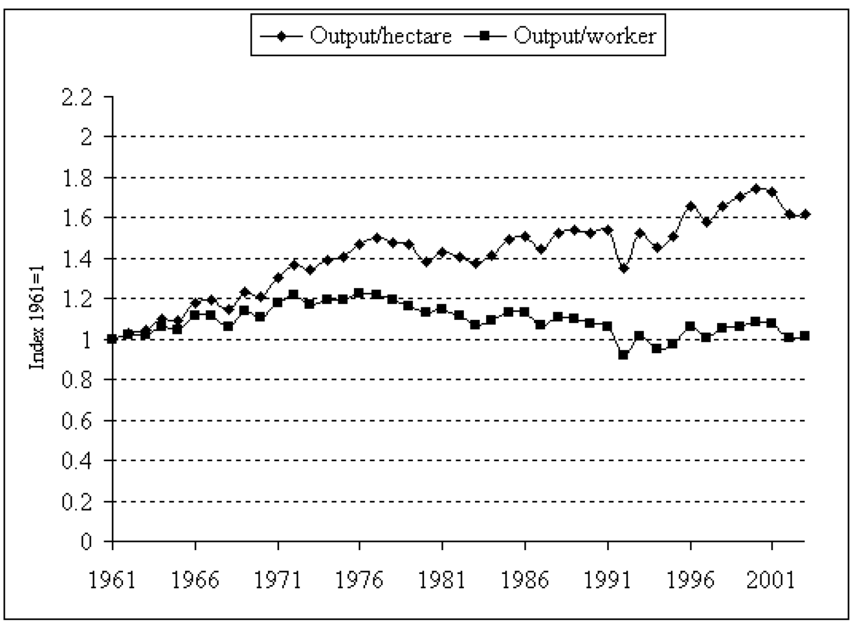


Figure 10b. Evolution of output per hectare and worker in SSA (I$) excluding Nigeria



Trends in TFP and TFP decomposition

There is a great variation in the performance and the contribution of different countries to total TFP growth in SSA between 1984 and 2003. In the first 10 years after the region started implementing new policies, two countries explain most of agricultural TFP growth: Nigeria and Ghana. Those countries contributed 61 and 17 percent, respectively, of total TFP growth occurring between 1984 and 1993. Other countries with a relatively significant contribution to TFP growth during that period are Sudan and Tanzania (Figure 11). Those four countries explain 94 percent of total TFP growth in SSA from 1984 to

1993. The number of countries contributing to TFP growth increased significantly between 1994 and 2003, with nine countries explaining 90 percent of TFP growth during that period. Nigeria remains the main contributor to TFP growth, but its contribution is down to 38 percent of total growth from 61 percent in 1984–1993. The contribution of Ghana is also down from 17 to 4 percent. Sudan, Ethiopia, Tanzania, Ivory Coast, Mali, Kenya, and Cameroon together explain almost 40 percent of SSA's TFP growth between 1994 and 2003 (Figure 11b).

Figure 11a. Contribution of different countries to TFP growth in SSA, 1984–1993

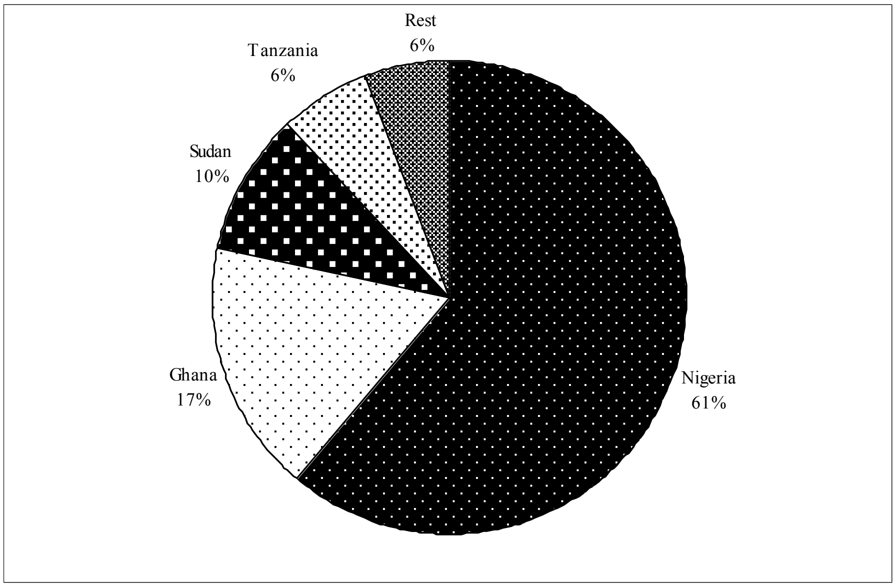
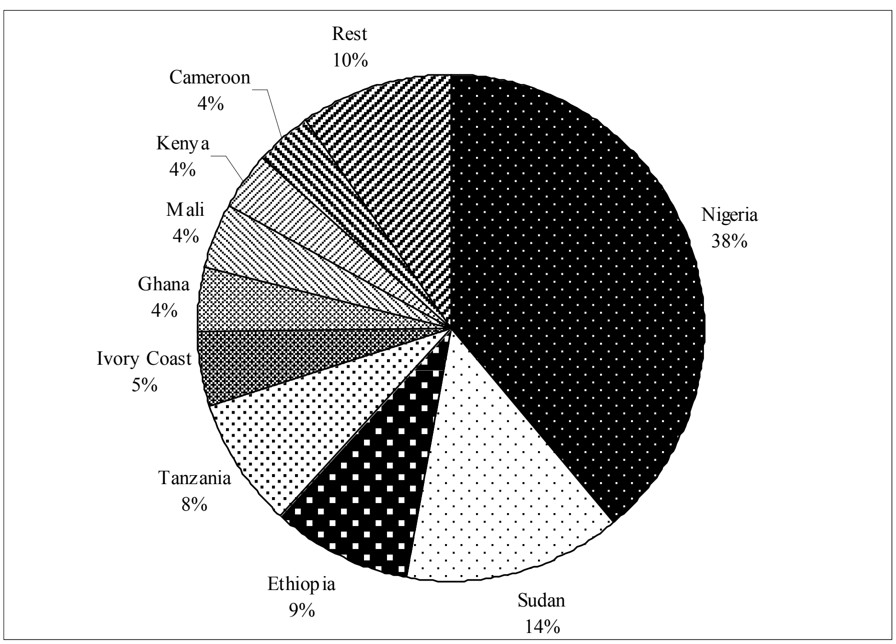


Figure 11b. Contribution of different countries to TFP growth in SSA, 1994–2003



Looking at agricultural TFP growth rates for individual countries between 1984 and 2003, we observe that TFP grew above 1.5 percent per annum in nine of the 30 countries in our sample (Table 4). Ghana with an average growth rate of 4.5 percent appears as the most dynamic country during this period. Benin and Nigeria with growth rates above 3 percent also show remarkable growth. However, this ranking changes if we consider the last 10 years of the period (1994–2003). As shown in the second column of Table 4 , Malawi, Mozambique, and Sudan are the countries with the best-performing agricultural sector in terms of TFP growth. Tanzania, Ethiopia, Chad, Gabon, Mauritania, Republic of Congo, and Burkina Faso also improved their performance significantly during this period. Nigeria and Ghana are still among the best Sub-Saharan African performers, although on average, TFP growth for those countries from 1994 to 2003 is lower than growth from 1984 to 2003.

Table 4. Ranking of countries by TFP growth performance

	1984–2003		1994–2003
Ghana	4.52	Malawi	3.35
Benin	3.51	Mozambique	3.32
Nigeria	3.15	Sudan	3.19
Malawi	2.13	Mali	2.85
Tanzania	1.94	Tanzania	2.79
Togo	1.78	Ethiopia	2.55
Cameroon	1.68	Chad	2.48
Gabon	1.61	Gabon	2.31
Mauritius	1.56	Nigeria	2.12
Zambia	1.49	Cameroon	1.84
Kenya	1.38	Ghana	1.79
Sudan	1.34	Benin	1.67
Mozambique	1.21	Ivory Coast	1.60
Chad	1.14	Mauritania	1.44
Ivory Coast	0.99	Congo	1.39
Guinea-Bissau	0.93	Burkina	1.32
Burkina Faso	0.91	Kenya	1.05
Congo	0.81	Mauritius	0.93
Zimbabwe	0.81	Togo	0.59
Ethiopia	0.71	Guinea-Bissau	0.45
Sierra Leone	0.66	Guinea	0.42
Mali	0.56	Zambia	0.03
Senegal	0.53	Madagascar	-0.03
Madagascar	0.43	Swaziland	-0.19
Guinea	0.31	Zimbabwe	-0.50
Swaziland	-0.22	Senegal	-0.70
Lesotho	-1.09	Sierra Leone	-0.75
Mauritania	-1.12	Lesotho	-1.28
Botswana	-1.18	Gambia	-1.38
Gambia	-1.20	Botswana	-3.99

Source: Authors' estimation.

Table 5 focuses on the most recent period (1994–2003), where TFP growth on average is higher than in the 1984–1993 period. The first column of this table shows that Coastal West Africa and East Africa are the regions with the best performance (1.89 and 1.90 percent per year, respectively). In Southern Africa, only two countries show a good performance (Malawi and Mozambique), while in the Sahel, results are mixed, with two countries showing significant TFP growth (Mali and Chad) and two countries with a good performance in historical terms (Mauritania and Burkina Faso).

Table 5. Annual TFP growth rate and TFP growth decomposition, 1994–2003 (percentage)

	TFP	Efficiency	Technical change
Benin	1.67	0.00	1.67
Cameroon	1.84	0.86	0.98
Congo, Rep.	1.39	1.39	0.00
Ivory Coast	1.60	1.37	0.24
Gabon	2.31	2.31	0.00
Ghana	1.79	1.79	0.00
Guinea	0.42	0.42	0.00
Nigeria	2.12	2.10	0.02
Sierra Leone	-0.75	-0.75	0.00
Togo	0.59	-0.19	0.78
Coastal W. Africa	1.89	1.71	0.17
Burkina Faso	1.32	1.24	0.09
Chad	2.48	2.06	0.42
Gambia	-1.38	-1.38	0.00
Guinea-Bissau	0.45	0.34	0.11
Mali	2.85	2.77	0.09
Mauritania	1.44	1.42	0.01
Senegal	-0.70	-0.91	0.21
Sahel	1.11	0.94	0.16
Botswana	-3.99	-3.99	0.00
Lesotho	-1.28	-1.93	0.65
Malawi	3.35	3.22	0.14
Mauritius	0.93	-0.39	1.31
Mozambique	3.32	3.32	0.00
Swaziland	-0.19	-2.34	2.15
Zambia	0.03	0.03	0.00
Zimbabwe	-0.50	-1.64	1.14
Southern Africa	1.48	1.16	0.31
Ethiopia	2.55	2.55	0.00
Kenya	1.05	0.37	0.68
Madagascar	-0.03	-0.03	0.00
Sudan	3.19	3.19	0.00
Tanzania	2.79	2.77	0.02
East Africa	1.90	1.72	0.17

Source: Authors' estimation.

Decomposition of TFP growth into its components (second and third columns in Table 5) 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, in the case of Coastal West Africa, only 0.17 percentage points in 1.89 percent growth in TFP (9 percent) results from technical change. A similar result is obtained in East Africa. Only TFP growth in Benin is explained totally by technical change, given that this country appears to be at the technological frontier during the 1994–2003 period. Cameroon and Togo also show a significant contribution of technical change to TFP growth, while technical change in Ivory Coast is above the average for the region.

The contribution of technical change to TFP is most important in Southern Africa, with values that are twice those in other regions. Swaziland, Lesotho, Zimbabwe, and Mauritius show a significant share of technical change in TFP growth, but their performance was poor due to growing inefficiency. On the other hand, Malawi and Mozambique, two of the countries with better performance in the region, show very little incidence of technical change on productivity growth. In East Africa, only Kenya shows a significant contribution of technical change to total TFP growth.

Changes in Output Structure

The contribution to output growth of different crops and livestock products depends on the agro-ecological conditions and the production possibilities of the different regions. As shown in Table 6, roots and tubers were major contributors to output growth in all regions with the only exception of the Sahel. Growth in oil crops also contributed significantly to growth in all regions. Traditional export crops (cotton) and rice made the largest contribution to output growth in West Africa, while maize and livestock (beef and milk) had a major role in output growth in East Africa. Other cereals and sheep and goat meat were important in the Sahel and Sudan.

Total output growth of different agricultural activities is highly concentrated in a few countries. Nigeria, Ghana, Malawi, and Mozambique explain almost 70 percent of total growth in roots and tubers. Ethiopia, Sudan, and Ghana concentrate almost 70 percent of total growth in oil crops. Almost 70 percent of total output growth in other cereals is explained by two countries: Ethiopia and Nigeria. Seventy percent of increased output of tropical fruits is explained by Nigeria, Ghana, and Kenya; and only Nigeria and Cameroon account for 70 percent of output growth in vegetables. Growth in rice production is a West Africa phenomenon, with the main contributors being Mali, Ivory Coast, Guinea, and Nigeria. Growth in beef and milk production occurred principally in the highlands of East Africa and in Sudan; while Nigeria and Sudan made the most significant contribution to growth in sheep and goat meat.

Table 6. Contribution of different subsectors to total output change by country, 1994–2003

	Rice	Maize	Other cereals	Oil crops	Pulses	Roots & tubers	Export crops	Tropical fruit	Vegetables	Other crops	Beef	Milk	Shoat meat	Chicken	Pig meat	Total
Malawi	2.2	11.9	1.2	13.8	4.0	73.4	-13.8	3.4	0.8	0.1	-0.2	-0.1	0.9	0.6	1.9	100.0
Mozambique	3.6	22.0	6.8	0.9	8.1	46.1	9.5	-3.2	-0.7	3.7	0.6	0.2	0.0	2.1	0.1	100.0
Sudan	0.2	0.1	6.0	27.5	4.1	0.1	4.1	1.6	3.8	0.3	19.6	16.8	15.5	0.3	0.0	100.0
Mali	22.7	2.3	0.8	5.1	1.4	1.9	39.9	1.5	2.1	0.1	5.9	2.6	11.8	1.9	0.0	100.0
Tanzania	2.3	10.4	6.0	0.9	11.2	14.1	4.4	0.3	5.0	9.2	13.8	15.0	2.2	4.4	0.8	100.0
Ethiopia	0.3	13.4	24.4	0.3	9.5	10.0	3.1	5.9	1.1	1.0	16.6	15.8	-1.5	0.1	0.0	100.0
Chad	3.4	0.0	18.8	38.4	10.6	3.8	7.1	0.0	1.2	0.3	7.1	3.6	5.4	0.2	0.0	100.0
Gabon	0.4	-0.3	0.0	7.9	0.0	8.5	0.9	42.8	4.5	29.0	-2.8	0.3	1.2	5.9	1.8	100.0
Nigeria	1.4	-6.6	14.5	26.2	6.9	16.4	3.9	6.4	16.7	3.5	2.8	0.5	3.8	1.1	2.6	100.0
Cameroon	0.6	8.1	4.3	14.3	13.4	9.0	17.0	-1.0	21.8	1.0	5.6	0.6	1.9	2.8	0.8	100.0
Ghana	2.6	4.2	-0.1	14.1	0.0	30.3	9.3	24.2	7.8	5.7	-1.2	0.3	1.4	1.5	-0.1	100.0
Benin	2.7	6.9	2.7	13.4	3.6	32.0	23.7	2.8	4.0	5.6	1.7	0.6	0.3	0.6	-0.7	100.0
Ivory Coast	10.9	3.1	0.3	1.4	0.0	0.6	56.8	5.9	2.9	10.2	5.1	0.2	0.1	2.9	-0.3	100.0
Mauritania	8.0	0.0	-13.0	0.4	7.4	0.5	0.0	0.0	0.1	0.3	17.5	8.3	69.0	1.6	0.0	100.0
Congo	-0.1	0.7	0.0	-7.1	2.8	51.8	6.4	39.7	-2.5	1.5	3.5	0.1	0.2	2.9	0.0	100.0
Burkina	1.8	7.3	13.9	18.5	9.1	0.3	23.0	0.1	-0.5	0.2	15.9	2.7	3.5	1.4	2.9	100.0
Kenya	-0.1	2.0	1.9	1.8	-4.2	12.7	14.1	13.8	3.7	3.3	16.9	29.1	1.2	2.7	1.1	100.0
Mauritius	0.0	-2.1	0.0	-3.9	0.0	-5.7	-88.9	5.2	27.8	0.0	1.0	-19.3	0.7	188.3	-3.1	100.0
Togo	6.9	19.2	1.9	5.3	6.6	17.5	38.7	0.2	-4.8	0.6	-0.1	0.5	5.6	3.7	-1.7	100.0
Guinea-Bissau	-20.3	0.0	20.3	2.4	-0.1	5.4	2.7	3.6	1.0	74.9	4.0	0.8	0.9	1.4	2.9	100.0
Guinea	26.2	0.8	0.3	23.2	0.0	16.0	3.7	10.5	1.7	0.4	10.1	2.9	3.0	0.9	0.3	100.0
Zambia	1.4	-90.3	5.7	19.1	-3.9	45.7	81.1	0.3	2.3	0.5	-1.0	-15.4	12.1	38.8	3.4	100.0

Source: Authors' calculations using data from FAOSTAT 2007.

Input Use, Input Relationships, and Partial Factor Productivity

In terms of the changes in the use of inputs, we are interested in how such changes affect labor and land productivity and through them overall TFP. Changes in those two partial productivity measures are driven by changes in the labor/land ratio, which is affected by increases in rural population and by the incorporation of arable land to crop production. If rural population and the number of agricultural workers grow faster than yields, the result is a deterioration of rural living standards. Increased labor productivity is needed to increase income of agricultural workers, which means that yields need to increase faster than the number of workers per hectare (Block 1995).

Several possibilities could result in terms of relative growth of labor and land productivity (see Block 1995), but according to our results, we can classify Sub-Saharan African countries into five groups (Table 7). A first group of countries shows an increase in land productivity with no increase or a small increase (less than 0.5 percent) in labor productivity. Within that group, Mauritania shows yield increases above 2 percent followed by Kenya and Zambia, with yield increases between 1 and 1.5 percent. In the case of Mauritania, the use of labor increases rapidly with almost no changes in arable land. To avoid reductions of labor productivity, Mauritania increases animal stock per worker. Something similar occurs in Tanzania. In Togo, output per worker is maintained by increasing the use of fertilizer per worker.

Table 7. Annual changes in input relationships, labor and land productivity, and TFP (%), 1994–2003

	Fertilizer per hectare	Tractors per hectare	Animal stock per hectare	Fertilizer per worker	Tractors per worker	Animal stock per worker	Worker per hectare	Output per hectare	Output per worker	TFP
Group 1	-2.60	-0.03	1.30	-3.52	-0.97	0.35	0.95	1.25	0.30	1.18
Togo	2.97	-2.27	1.33	2.41	-2.80	0.77	0.55	0.96	0.41	0.59
Zambia	1.25	-0.03	0.46	0.48	-0.79	-0.31	0.77	1.23	0.46	0.03
Kenya	0.29	0.77	-0.82	-0.88	-0.40	-1.97	1.18	1.30	0.11	1.05
Tanzania	-14.94	0.38	1.69	-15.50	-0.28	1.02	0.66	0.74	0.09	2.79
Mauritania	-2.55	1.01	3.87	-4.09	-0.59	2.23	1.60	2.02	0.41	1.44
Group 2	4.41	-0.82	1.49	3.88	-1.33	0.98	0.51	2.42	1.90	2.41
Mali	3.97	-0.44	2.04	3.42	-0.96	1.51	0.52	2.25	1.72	2.85
Congo	4.14	-0.54	1.59	3.90	-0.77	1.36	0.23	1.68	1.45	1.39
Chad	10.71	-0.31	2.52	9.73	-1.19	1.62	0.89	2.71	1.80	2.48
Cameroon	1.29	0.00	2.19	0.59	-0.69	1.49	0.69	2.62	1.91	1.84
Ethiopia	1.70	-1.79	1.63	1.01	-2.46	0.94	0.68	2.49	1.79	2.55
Mozambique	4.63	-1.85	-1.01	4.60	-1.88	-1.05	0.04	2.79	2.75	3.32
Group 3	1.81	-1.22	0.18	2.65	-0.42	0.99	-0.81	1.97	2.80	2.23
Malawi	7.34	-2.63	-1.20	8.95	-1.17	0.28	-1.48	3.23	4.78	3.35
Ghana	5.27	-3.96	-1.48	6.66	-2.68	-0.17	-1.31	1.57	2.92	1.79
Ivory Coast	4.75	-0.25	1.01	5.17	0.15	1.42	-0.40	2.09	2.50	1.60
Sudan	0.19	-0.29	1.39	0.33	-0.15	1.53	-0.14	1.64	1.78	3.19
Burkina Faso	-1.26	-1.07	0.52	0.21	0.40	2.01	-1.46	1.25	2.76	1.32
Nigeria	-5.45	0.85	0.82	-5.40	0.90	0.88	-0.06	2.02	2.08	2.12
Group 4	-0.39	-1.15	0.61	1.59	0.76	2.54	-1.90	0.66	2.62	1.33
Benin	6.37	-3.58	-2.73	10.34	0.02	0.90	-3.60	0.07	3.81	1.67
Mauritius	-2.12	0.00	2.75	-0.37	1.78	4.58	-1.75	0.97	2.76	0.93
Gabon	-2.76	-0.73	0.00	-1.25	0.81	1.55	-1.53	0.75	2.31	2.31
Guinea	-3.05	-0.27	2.41	-2.35	0.45	3.14	-0.72	0.87	1.60	0.42
Group 5										
Guinea-Bissau	10.36	-2.73	-1.17	11.25	-1.95	-0.37	-0.80	-0.13	0.67	0.45

Note: Group 1 shows an increase in land productivity and small or no growth in labor productivity. Group 2 shows growing rural population but faster growth in yields and increasing labor productivity. In group 3, labor productivity grows faster than yields. Group 4 shows declining agricultural workforce or slow population growth with expansion of arable land. In group 5, land grows faster than labor and there is negative growth in yields.

A second group of countries (group 2) shows a growing rural population as in the case of group one (growing number of workers/hectare), but these countries show a faster increase in yields than in population, and so output per worker also increases. To increase yields, Cameroon, Chad, Ethiopia, Mali, Congo, and Mozambique all increase the use of fertilizer and animal stock per worker.

Group 3 is similar to group 2 in that all countries increase both labor and land productivity, but in these countries labor productivity grows faster than yields. That occurs because these countries are increasing land productivity while the number of workers grows slowly or because countries are still increasing the number of hectares of arable land at a fast pace. In both cases the result is a slow growth of the number of workers per hectare. In general, it can be verified that most countries in this group are increasing the number of workers in agriculture, but many of them are reducing the number of workers per hectare because they are incorporating new land to crop production. That is the case in Ghana, Malawi, and Burkina Faso. These same countries also have high increases in yields, which can be explained by an increase in the use of fertilizer and animal stock per hectare. Ivory Coast, with no major changes in the number of workers and land, increases fertilizer and animal stock and by doing so is able to increase labor and land productivity in similar proportions. Nigeria obtains a similar result as Ivory Coast by reducing fertilizer use but increasing animal stock and the number of tractors per hectare and worker. In the case of Sudan, the major increases occur in animal stock.

Countries in group 4 show a declining agricultural workforce (Mauritius and Gabon) or low rural population growth with growth in arable land (Benin and Guinea) and no or low changes in yields. Better efficiency in the use of labor or implementation of labor-saving technologies is needed to maintain output with fewer workers. Benin increased significantly the use of land in crop production with low changes in the number of workers. To keep yields constant, that country increased the use of fertilizer per hectare. Results for Guinea are similar to those in Benin. Increases in labor productivity are obtained by the use of more animal stock and tractors. Gabon and Mauritius are the only countries reducing labor in absolute value. To keep production, those countries increased the number of tractors and animal stock per worker.

Guinea Bissau is the only country in group 5. In this country, the use of both land and labor increases, but land increases faster and yields show negative growth rates. This means that a reduction in the number of workers per hectare cannot be compensated for by growth in labor productivity. This can be seen by comparing Guinea Bissau with Benin in group 4. Yield growth is almost zero in both countries, but Benin was more successful increasing output per worker by increasing tractors per worker and animal stock per worker.

It is important to notice that there is also great variability in changes in the use of fertilizer in different countries. Although, as discussed above, the trend in recent years shows a reduction in the use of fertilizer in SSA, most of that reduction (72 percent) occurred between 1994 and 2003 and is explained by only one country, Nigeria. As Tanzania, Zambia, Zimbabwe, and Malawi account for 27 percent of the total reduction in fertilizer, those four countries together with Nigeria explain 99 percent of the total decrease in fertilizer use in SSA. On the other hand, 21 countries in our sample increased the use of fertilizer: Ethiopia, Ivory Coast, and Kenya explain 50 percent of this growth between 1983 and 2003.

To conclude, the 12 countries in groups 2 and 3 are the best-performing countries. These two groups show on average similar growth in TFP and increased labor and land productivity, which can be explained by increased used of fertilizer per hectare and worker. Countries in these two groups are more likely to have 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 they were still able to incorporate more land into crop production, given that the rural population is 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 improve rural income.

4. FACTORS BEHIND IMPROVED PERFORMANCE OF SUB-SAHARAN AFRICA'S AGRICULTURE

A study by Block (1995) finds that SSA reversed its poor performance of the 1970s and started a period of productivity growth in 1973–1978. That performance was sustained until 1983–1988, the last year for which information was available at that time. In that study, an econometric analysis is conducted to measure the contribution of different factors to increased agricultural TFP. Block finds that technical change, measured by expenditures for agricultural research, and macroeconomic reform, which leads to improved economic incentives for agriculture, might account for up to two-thirds of this recovery. With new evidence after more than a decade since the publication of Block's article, we explore in this section the relationship between our TFP estimates and factors affecting agricultural TFP in SSA. As a rigorous econometric analysis is beyond the scope of this study, we focus on the analysis of macro and agricultural policy reform, comparing major milestones in the process of policy reform in different countries with TFP changes in those countries. We then relate TFP changes to indicators of policy change and of agricultural performance. The analysis at the country level and the fact that we now have 15 more years than Block's original time series gives us a better perspective of the process of policy adjustment and the factors that explain that process. In the case of R&D investment, which also contributed to the recovery of the agricultural sector according to Block's analysis, we highlight the important contribution of some of the technical innovations in the improved performance of agriculture in SSA.

Results of our analysis suggest a link between policy changes in Sub-Saharan African countries between the mid-1980s and the second half of the 1990s and the improved performance of the agricultural sector. We find that the initial period of improved performance and TFP growth that stretches from 1985 to 1994 is driven mainly by policy changes in Nigeria and Ghana (see the next two sections for a detailed discussion of the nature of such changes). In the early 1990s, and mostly after the devaluation of the CFA franc in francophone West Africa (January 13, 1994), several countries improved their performance, extending and consolidating the recovery of the agricultural sector across the continent. The devaluation of the CFA franc allowed the recovery of large agriculture producers such as Ivory Coast and Cameroon, and of Sahelian countries such as Mali and Burkina Faso. By that time, policy changes were starting to show results in Eastern and Southern African countries. Those changes together with the end of internal conflicts resulted in improved economic performance in Sudan, Ethiopia, and Mozambique. Other countries that started the reform in the 1980s but struggled with its implementation (Malawi and Kenya) were finally able to show progress also by the mid-1990s.

Policy Reform in Sub-Saharan Africa

In 1994, the World Bank published a study intended to "assess how much policy reform has taken place in Africa, how successful it has been, and how much more remains to be done." That study (World Bank 1994) concludes that progress has been made, but reforms remain incomplete. It also stresses the fact that the main factors behind the poor performance of SSA's economy between the mid-1960s and the 1980s were poor macroeconomic and sectoral policies. According to the World Bank, the strategy African governments followed in the two decades between 1965 and 1985 resulted in overvalued exchange rates; prolonged budget deficits; protectionist trade policies and government monopolies that reduced competition, negatively affecting productivity; and heavy taxation of 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 emphasized by Kherallah et al. (2000), 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.[6]

Policy reforms have been uneven across sectors and across countries and occurred in two major waves. The first wave of reforms started in 1984–1985. 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 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 have been decontrolled and marketing boards eliminated (except in some countries for key exports such as cotton and cocoa). Current account convertibility has been achieved; trade taxes have 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 agriculture reform, most policy changes took place after 1986–1987, 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 Sub-Saharan Africa was more than halved between 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 is 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 have withdrawn 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) explain 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: Benin (tubers); Ethiopia (teff, maize, wheat); Mali (millet, sorghum); Tanzania (maize); Malawi and Zambia partially (maize); no changes in Kenya and Zimbabwe (Kherallah 2000).

Despite the mixed performance in eliminating fertilizer subsidies, policy changes had a negative impact on the fertilizer use in the region. That was a consequence of the elimination of fertilizer subsidies in some countries, the depreciation of the real exchange rate, and the liberalization of fertilizer imports

[6] The reforms included four types of measures as summarized by Kherallah et al.: (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.

and distribution. As a result, the fertilizer/crop price ratio increased significantly in the region (exceptions were Ethiopia, Kenya, and Zimbabwe). In 2003, the amount of fertilizer used in SSA decreased to 1.24 million tons compared with 1.26 million tons in 1983. That change is small (less than 2 percent), but it is in sharp contrast with high growth in fertilizer use in the 1970s and 1980s. The difference also hides changes in the use of fertilizer in different countries. Nine countries reduced the use of fertilizer in 2003 compared with their use in 1983 by 0.34 million tons in total. Nigeria accounts for 71 percent of that reduction. That country together with Tanzania, Zambia, Zimbabwe, and Malawi account for almost all (99 percent) of the reduction in the use of fertilizer in 2003. On the other hand, 21 countries in our sample increased the use of fertilizer (a total of 0.32 million tons). Ethiopia, Ivory Coast, and Kenya explain 50 percent of this growth, and those countries together with Benin, Cameroon, and Mali explain more than 80 percent of growth in fertilizer use between 1983 and 2003.

Linking Policy Reforms with TFP Growth in Agriculture

Since the implementation of the structural adjustment, policymakers and academics have argued about the causes of and the solutions to the African crisis and the impact of the structural adjustment promoted by the international financial institutions in the 1980s and 1990s (see, for example, Bar-on 1997; Arndt et al. 2000; Mosley et al. 1995; Kraev 2004; Mkandawire 2005). Our analysis doesn't intend to contribute to this debate about the overall effect and impact of the reforms. It rather tries to find evidence of the impact of policy changes (if any) on agricultural performance of Sub-Saharan African countries, measured as TFP growth. To do that, we compare different indicators with TFP growth at the regional and at the individual country level. We present three different pieces of evidence. First, we compare indicators of policy change with agricultural TFP growth in different Sub-Saharan African countries. Second, we relate changes in agricultural gross domestic product (AgGDP), agricultural exports and imports, and production of export and staple crops with the period of policy changes. Finally, we relate the evolution of agricultural TFP in selected countries with milestones in policy reform by analyzing the TFP series for structural change.

Policy Change Indicators and Agricultural TFP

Table 8 ranks the performance of a group of Sub-Saharan African countries in terms of the progress made in macroeconomic and agricultural policy reform. The index that we use to rank performance in macroeconomic policy reform is an index of policy stance elaborated by the World Bank.[7] The index measuring performance in agricultural policies is adapted from Cleaver and Donovan (1995), who elaborated a rating of countries by performance in four areas: agricultural policy, fertilizer use, quality of national extension systems, and quality of infrastructure.[8] Both indices take values between 1 and 4, with 1 representing "best policies." Figure 12 relates the policy index of each country with agricultural TFP growth between 1994 and 2003. The results show a statistically significant relationship (5 percent level) between improved policies and performance of the agricultural sector (Figure 12a), and also a strong relationship between agricultural policies and TFP (Figure 12b). In this case, the slope of the trend line explaining the relationship between TFP and agricultural policies is –0.59 and is significant at the 1 percent confidence level.

[7] The index includes fiscal policy stance based on the budget deficit including grants; monetary policy stance based on seigniorage, inflation, and the real interest rate; and exchange rate policy stance based on the change in the real exchange rate between 1980 and 1990–1991. We updated the exchange rate index of francophone West African countries to include the 1994 devaluation of the CFA franc. See World Bank (1994, app. B, pp. 266–69).

[8] Cleaver and Donovan's rating distinguishes only two categories of countries: those that are "performing well" and those that are not. We gave a score of 1 to those performing well in each category and a score of 4 to the rest in order to be in the same range of values as the World Bank index of macro policy stance.

Table 8. Rating countries by performance in changing macroeconomic[a] and agricultural[b] policies, 1981–1986 to 1987–1991

	Fiscal[c]	Monetary[d]	Exchange rate	Total macro policy	Ag policy[e]	Fertilizer[f]	Extension[g]	Infrastructure[g]	Overall agriculture	Overall policy
Benin	1.00	0.67	0.33	2.70	0.70	0.10	0.10	0.40	1.60	2.15
Burkina Faso	0.67	0.33	0.33	2.00	0.70	0.10	0.10	0.40	1.60	1.80
Burundi	0.67	0.33	0.67	1.70	0.70	0.40	0.40	0.40	1.90	1.80
Cameroon	1.33	0.57	1.33	3.20	2.80	0.10	0.40	0.40	3.70	3.45
CAR	1.00	0.43	1.00	2.40	0.70	0.40	0.40	0.40	1.90	2.15
Chad	—	—	—	—	2.80	0.10	0.40	0.40	3.70	—
Congo	1.33	0.67	1.33	3.30	0.70	0.10	0.40	0.40	1.90	2.60
Ivory Coast	1.33	0.43	0.67	3.10	2.80	0.10	0.10	0.10	3.10	3.10
Gabon	0.67	0.43	0.33	2.10	0.70	0.40	0.40	0.40	1.90	2.00
Gambia	0.33	0.67	0.67	1.70	—	—	—	—	—	—
Ghana	0.33	0.57	0.33	1.20	0.70	0.10	0.10	0.40	1.30	1.25
Guinea	—	—	—	—	0.70	0.10	0.10	0.40	1.30	—
Kenya	1.00	0.67	0.33	2.00	0.70	0.10	0.10	0.10	1.30	1.65
Madagascar	1.00	0.50	0.33	1.80	0.70	0.40	0.40	0.40	1.90	1.85
Malawi	0.67	0.57	0.67	1.90	0.70	0.40	0.10	0.10	1.00	1.45
Mali	1.00	0.33	0.33	2.30	0.70	0.10	0.10	0.40	1.60	1.95
Mauritania	0.33	0.50	0.67	2.20	2.80	0.40	0.40	0.40	3.70	2.95
Mauritius	—	—	—	—	0.70	0.40	0.40	0.10	1.60	—
Mozambique	1.33	1.00	1.33	3.70	0.70	0.10	0.40	0.40	1.90	2.80
Niger	1.33	0.57	0.67	2.60	0.70	0.10	0.10	0.40	1.30	1.95
Nigeria	1.00	0.57	0.67	2.20	0.70	0.40	0.10	0.40	1.30	1.75
Rwanda	1.00	0.67	1.00	2.70	0.70	0.40	0.40	0.40	1.90	2.30
Senegal	0.33	0.57	1.33	2.20	2.80	0.10	0.40	0.40	3.70	2.95
Tanzania	0.33	1.00	1.33	2.70	0.70	0.40	0.10	0.40	1.30	2.00
Togo	0.67	0.57	0.33	2.20	0.70	0.10	0.10	0.40	1.30	1.75
Uganda	1.00	0.67	0.67	2.30	0.70	0.10	0.10	0.40	1.30	1.80
Zambia	1.33	1.33	1.33	4.00	2.80	0.40	0.10	0.40	3.70	3.85
Zimbabwe	1.33	0.77	0.67	2.80	2.80	0.40	0.10	0.10	3.40	3.10

Source: Adapted by authors from World Bank (1994) and Cleaver and Donovan (1995 — = not applicable.

[a] Built using an index of policy stance. For each policy, countries were classified as having a good/adequate, fair, poor, or very poor stance and assigned a numerical score from 1 to 4, with a smaller number indicating a better policy stand. Individual scores were added using equal weights.

[b] Built using rating of countries in Cleaver and Donovan (1995). A value of 1 or 4 was assigned if policies were good or poor, respectively. Values are added giving larger weight to agricultural policies (0.7) and 0.1 to each of the other areas.

[c] Fiscal policy includes fiscal balance, change in total revenue.

[d] Monetary policy includes change in seigniorage and change in inflation.

[e] Countries were judged to be "performing well" regarding agricultural policy if they either reduced overall taxation of agriculture or raised real producer prices for agricultural exports in the period 1981/83–1989/91.

[f] Good performance means that fertilizer used per hectare is increasing at more than 3 percent from 1993 to 2003.

[g] Based on World Bank evaluation (see Cleaver and Donovan 1995, pg 42.

Figure 12a. TFP growth and overall policy ratings (macro and agricultural policies) for Sub-Saharan African countries, 1994–2003

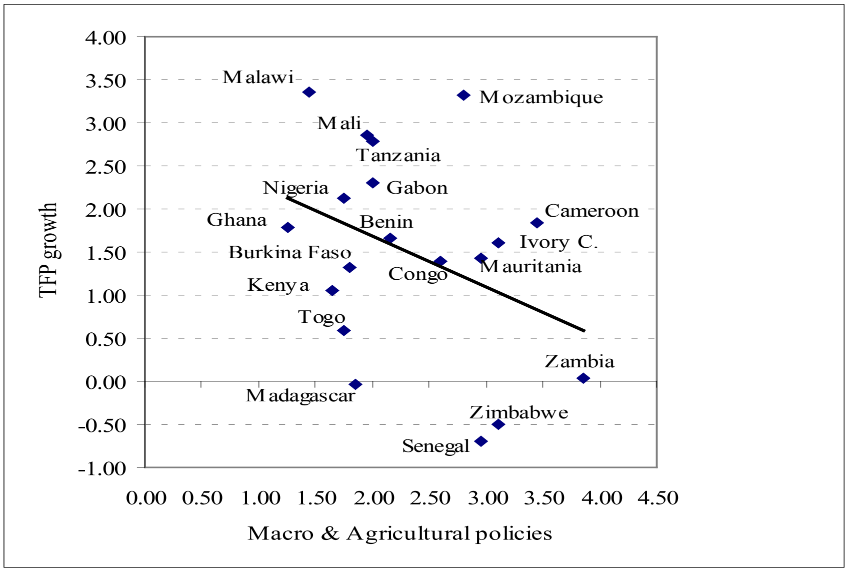
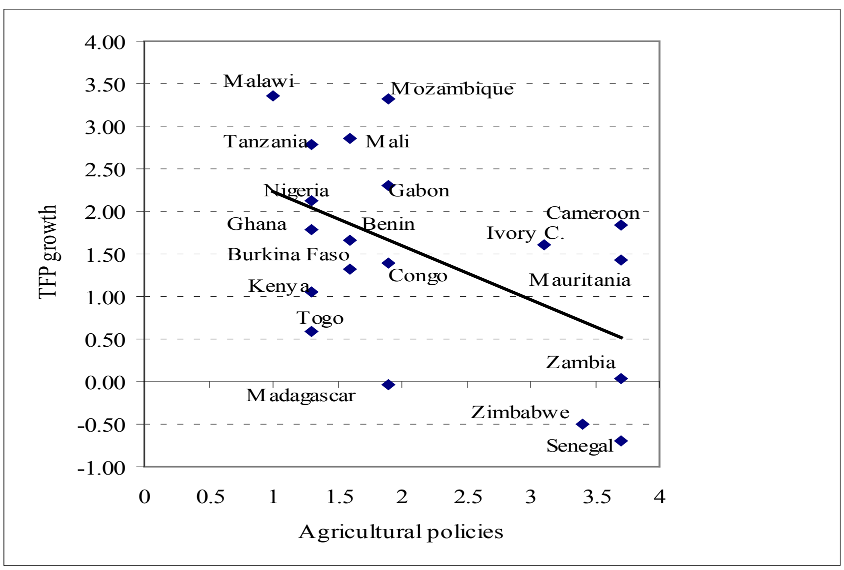


Figure 12b. TFP growth and agricultural policy ratings for Sub-Saharan African countries, 1994–2003



Source: Adapted by authors from World Bank (1994) and Cleaver and Donovan (1995)

Policy Change and the Evolution of Agricultural Production and Trade

Policy changes in several Sub-Saharan African countries were expected to have negative impacts on agricultural terms of trade given the elimination of fertilizer subsidies in a context of low international commodity prices and high protection in high-income markets. Even though devaluation of local currencies might have had a positive effect on agricultural exports, it also reinforces the negative effect of policies on fertilizer prices. In this context we could expect that policy changes in Sub-Saharan African countries resulted in deteriorated terms of trade, decreased competitiveness for agriculture, and negative or at least no effect on exports. Related to this, the study by Boratav (2001) finds that those countries and commodities where significant moves toward deregulation have occurred had not experienced improvements in agricultural prices. However, the difference in AgGDP growth in the agricultural sector and the export performance before and after the reform in many of the countries that changed their policies suggests a different story. According to the World Bank (2008), during the 1990s more favorable world commodity prices and continued macroeconomic and agricultural reforms led to larger increases in real domestic prices of agricultural exports. Those price incentives explain part of the higher agricultural growth in many of the countries in SSA.

Figure 13 shows the pre- and postreform evolution of different agricultural production and trade indicators. Figure 13a shows AgGDP of the group of countries that accounts for almost 90 percent of SSA's TFP growth during the 1990s compared with AgGDP of the whole SSA region. Figure 13b presents agricultural exports, imports, and total trade (exports + imports) for the group of countries that explains 92 percent of total TFP growth in SSA. Finally, Figure 13c shows the evolution of production of export and staple crops also before and after the reform. There is a clear coincidence between the period of policy changes and an improved performance of the agricultural sector both in terms of production and exports. AgGDP growth accelerates from 2.0 percent in 1968–1983 to 3.0 percent per annum in 1984–1993 in the studied countries. More significantly, agricultural exports showing average negative growth in 1968–1983 increase at an average rate of 3.6 percent in 1983–1994. Production of both export crops and cereals accelerates in 1984–2003, with growth rates that almost double compared with growth rates in 1964–1983. The policy reforms appear to be related also with a more open agricultural sector after 1994 given the increase in imports and total trade, which could be one of the factors explaining increased efficiency in agriculture.

Figure 13a. Policy change and trends in agricultural GDP in SSA

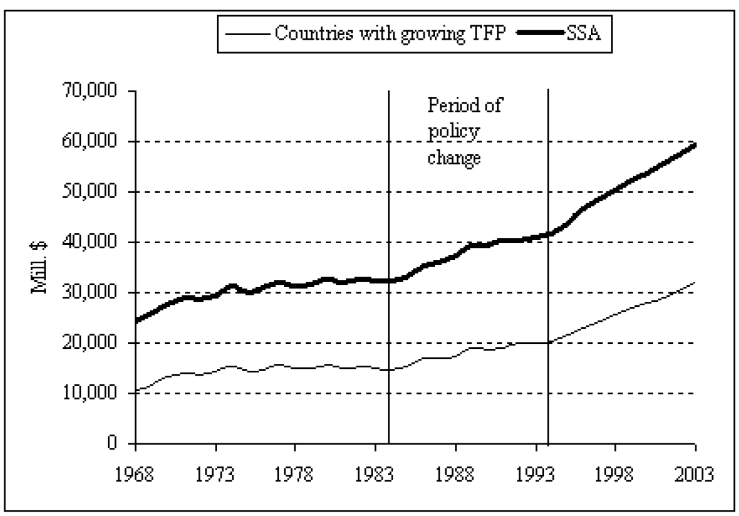


Figure 13b. Policy change and trends in agricultural trade in SSA

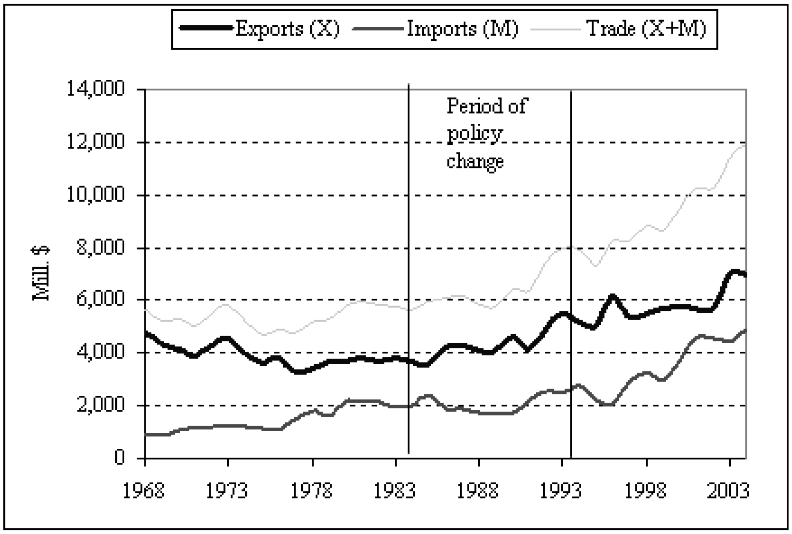
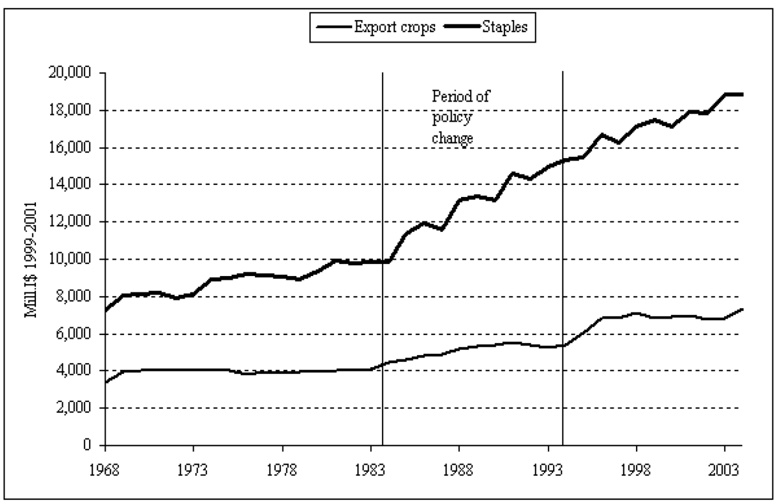


Figure 13c. Policy change and trends in production of major groups of crops in SSA



Cleaver and Donovan (1995) offer an explanation for the positive impact of policy reform in agriculture in the face of declining international prices for exports in the late 1980s and early 1990s. According to those authors, "ten countries improved policies by increasing or allowing increases in real producer prices for exports enough to more than offset the international decline: Benin, Burkina Faso, Ghana, Madagascar, Mali, Mozambique, Niger, Nigeria, Tanzania and Togo. These countries achieved this by a combination of lowering export taxes, raising administered producer prices, reducing marketing costs (usually by deregulation and de-monopolization of export marketing), and depreciating the exchange rate of the domestic currency." On the other hand, inadequate policies reinforced the price declines experienced in world markets in eight countries: Cameroon, Chad, Ivory Coast, Gambia, Guinea Bissau, Rwanda, Senegal, and Zambia. Differences in the implementation of policy changes and incentives help to explain the variability in terms of TFP improvements among Sub-Saharan African countries.

Policy Milestones and Structural Change in TFP Series

We now look at the best-performing countries in terms of TFP growth in SSA, separately analyzing the evolution of TFP in those countries and relating that evolution to specific milestones in policy reform. These relationships are presented in Table 9 for 11 countries that together explain more than 90 percent of total TFP growth in SSA in the period 1994–2003. Of those 11 countries only Kenya shows no correspondence between TFP growth and policy changes, which suggests that for that country, other factors played a more significant role than policy as determinants of TFP performance. In what follows, we discuss in more detail some of the milestones in the process of policy change in these countries and test the TFP series for structural change relating those milestones with policy changes for each individual country.

Table 9. Summary of policy events and changes in selected Sub-Saharan African countries

	Before structural adjustment			After structural adjustment		
	Period	Policy	% TFP growth	Period	Policy changes	% TFP growth
Nigeria	1964–1984	Overvalued currency; public expenditure concentrated in sectors other than agriculture; price controls and trade restrictions; parastatal marketing boards; subsidized consumption; massive agricultural imports; fertilizer subsidy	-3.45	1985–2003	Structural adjustment program: devaluation of the naira; ban on food imports; Agricultural Development Projects (ADPs)—National Coordinated Research on Cassava Project was set up to coordinate on-farm adaptive research on cassava	3.43
Ghana	1964–1983	Socialist policy targeting food import substitution; promotion of mechanization; grain marketing board	-3.48	1984–2003	Economic recovery program; trade liberalization and foreign exchange controls lifted	4.52
Ethiopia	1974–1993	Command economy; recurrent drought; long and devastating civil war; narrow range of exports; very low technology base	-0.27	1994–2003	Package of economic reform measures implemented by the government that came to power in 1991	2.55
Sudan	1964–1992	Interventionist policy; distorted markets; war and rainfall fluctuations; several million displaced in the southern region	-0.88	1993–2003	Long-term plan with substantial economic reforms: currency devaluation; exchange rate liberalization; abolition of most export and import licenses; liberalization of most domestic markets	1.74
Ivory Coast	1964–1994	Ineffective policies; debt crisis in the 1980s; overvalued currency; little progress in reforms until 1994	-0.45	1995–2003	After adjustment program 1994–1996, Ivory Coast made considerable progress in reducing financial imbalances, controlling inflation, and liberalizing the economy (cocoa and coffee sectors); devaluation of CFA franc in 1994[a]	1.80

Table 9. Continued

	Before structural adjustment			After structural adjustment		
	Period	Policy	% TFP growth	Period	Policy change	% TFP growth
Cameroon	1964–1994	Drop in commodity prices (petroleum, cocoa, coffee, and cotton) in the mid-1980s; overvalued currency; high cost structure induced by oil revenues; economic mismanagement; recession. Real per capita GDP fell by more than 60% from 1986 to 1994	-0.39	1995–2003	Economic reform programs supported by World Bank and IMF began in the late 1980s; CFA franc was devalued by 50% in January 1994; government failed to meet the conditions of the first four IMF programs until the devaluation of the CFA franc	2.11
Mali	1964–1994	Socialist-inspired policies; state intervention; nationalization; state-owned enterprises in several sectors; public monopoly on foreign trade; price controls	-0.66	1995–2003	Reforms implemented in 1992–1995; liberalization of regulatory environment; elimination of price controls; import quotas eliminated in 1988; export taxes dropped in 1991; reform program of the public enterprise sector; devaluation of CFA franc in 1994	2.41
Malawi	1964–1994	Agricultural production and marketing heavily controlled by government;slow progress in agricultural reforms after 1981	-0.23	1995–2003	All input and output prices were set free except for maize; production and marketing of hybrid seed maize liberalized; fertilizer subsidy still used	4.39
Mozam-bique	1975-1992	Centrally planned economy after independence; 10-year plan launched in 1981; Economic problems; conflict and civil war; draught and collapse of the economy in 1986	3.04	1993-2003	Economic and social rehabilitation program introduced reforms in 1989; price liberalization in 1989–1993; trade liberalization and simplified tariff structure since 1996; privatization program implemented (1989); end of civil war, 1993	.14
Kenya	1964-1993	Structural reforms started in the 1980s but small improvement by 1991; slow pace in changing agricultural policy	2.24	1994-2003	Liberalization of maize market and abolition of maize movement controls, 1994; progress made on fertilizer policy, cereals marketing policy, and output marketing for a variety of enterprises including cotton, dairying, sugar, and coffee	1.05

Table 9. Continued

	Before structural adjustment Period	Policy	% TFP growth	After structural adjustment Period	Policy change	% TFP growth
Tanzania	1975-1985	Heavily state-controlled economy; inadequate policy led to economic stagnation; war with Uganda	-0.43	1986-2003	Economic recovery program began in mid-1986: currency devaluation; international and domestic trade and marketing liberalization; reduction of fiscal deficit; reduction in tariff levels; elimination of price controls; phasing out of petroleum and fertilizer subsidies; a hiring freeze and retrenchment in the civil service	2.79

Source: Elaborated by authors based on several sources referred to in the text
[a] International Monetary Fund (1998).

The disastrous evolution of Nigeria's agriculture since the late 1960s and until 1985 is explained by the growing importance of oil exports and the policies followed during that time, which reinforced the negative impact of an overvalued naira. Public expenditure neglected agriculture, and markets were distorted by price controls, trade restrictions, fertilizer subsidies, and the inefficient operation of marketing boards. The government used the overvalued naira to subsidized consumption with massive imports of grain. Policy changes started in 1985 when the Nigerian government banned the import of grains and the export of yam and cassava products and adopted a structural adjustment program that consisted of a number of policy reforms, including the devaluation of the naira. Public expenditure in agriculture increased, and the government launched the Agricultural Development Projects, which focused on extension and input distribution for small farmers and on rural infrastructure (see Cleaver and Donovan 1995 and Nweke 2003).

As in Nigeria, and in most other countries in SSA, the performance of Ghana's agricultural sector was very poor during the 1960s and 1970s. The government of Ghana maintained a socialist policy and aimed at rapid industrialization, favoring grain production by public farms as a food import substitution crop. In 1962, the government established the State Farms Corporation and encouraged production of grains with a price support program through the Grains Marketing Board and the Food Distribution Corporation and subsidized irrigation water, farm mechanization, and agricultural credit. From 1960 to 1962, 20 percent of total government capital expenditure on agriculture was invested in farm mechanization. With poor economic results and after a severe drought in 1982–1983, the government launched an Economic Recovery Plan under which trade was liberalized and foreign exchange controls lifted (Nweke 2003).

In the case of francophone African countries, the reforms of the late 1980s and early 1990s started to pay off only after the devaluation of the CFA franc in January 1994. The overvalued currency was one of the major factors affecting the performance of agriculture in Ivory Coast, Cameroon, Mali, Benin, Chad, Guinea, and Togo. Cameroon, like Nigeria, also suffered the impact of high costs induced by oil revenues, which made this country marginally competitive until the devaluation in 1994. Reforms in Mali started in 1988 with a program signed with the World Bank and the International Monetary Fund (IMF) eliminating price controls on consumer goods, import quotas, and export taxes and reforming the public enterprise sector. By 1994–1996, all reforms were in place (see Cleaver and Donovan 1995).

Policy changes in East Africa (Ethiopia, Sudan, and Tanzania) started showing results also in the mid-1990s. According to Cleaver and Donovan (1995), after a dismal performance that resulted from a combination of a command economy, recurrent drought, a long and devastating civil war, a narrow range of exports, and a very low technology base, agricultural production in Ethiopia started recovering after

1995. That improved performance was the result of a package of economic reform measures implemented by the government that came to power in 1991.

Sudan's government adopted an ambitious long-term plan and commenced substantial economic reforms in early 1992 despite the civil war affecting the country between 1983 and 2005. That plan included currency devaluation, exchange rate liberalization, abolition of most export and import licenses, and liberalization of most domestic markets.

In the case of Kenya, reforms have been slow and marked by many setbacks. Liberalization of the maize market and abolition of maize movement controls were achieved in early 1994, and progress was made on fertilizer policy, cereals marketing policy, and output marketing for a variety of enterprises, including cotton, dairying, sugar, and coffee. Progress made in policy reform, however, still needs to show in TFP, which has been low in the 1990s. This could be explained in part by the effect of six years of drought that affected the country during the 1990s.

Tanzania also made progress in policy reforms that resulted in improved performance of the agricultural sector. After a new government was elected in 1985, the Economic Recovery Program began in mid-1986, with reforms that included "substantial currency devaluation (1987–1992); import liberalization; domestic trade liberalization; liberalization of food grain and export marketing; reduction of the fiscal deficit; export retention schemes and legalization of foreign holding; reduction in tariff levels; liberalization of cashew marketing (1992); elimination of price controls on everything except sugar, petroleum, and fertilizer; phasing out of petroleum and fertilizer subsidies; a hiring freeze and retrenchment in the civil service. . There has been increase in food production, increase of traditional exports and a five-fold increase in non-traditional agricultural exports since 1985" (Cleaver and Donovan 1995).

In Southern Africa, Mozambique was added to the list of countries making progress in policy reform in the 1990s, moving away from a centrally planned economy and a civil war that affected the country for several years. The country launched a structural adjustment program in 1987, but the economy did not start to show signs of recovery until the end of the civil war in 1992. In the subsequent three years, the government steered the economic reintegration of the displaced population, the demobilization of 80,000 troops, and the return to democracy. Presidential and parliamentary elections were held in November 1994 (International Monetary Fund 1999). According to Arndt et al. (2000), a decade after the start of the stabilization and the implementation of a heterodox adjustment program, and after five years of peace, macroeconomic stabilization has arrived in Mozambique. Arndt emphasizes that despite progress made by the agricultural sector, it is still far from attaining its potential performance, using crude technologies that will require both technological and extension breakthroughs on a massive scale.

As in other Sub-Saharan African countries, prior to 1981 agricultural production and marketing in Malawi were heavily controlled by the government. We follow Kherallah and Govindan (2000) to briefly characterize Malawi's policies in the 1970s and early 1980s and the changes implemented under structural adjustment. Until 1981, input distribution, output purchases, and prices in Malawi were controlled by the parastatal Agricultural Development and Marketing Corporation (ADMARC). Input prices were also subsidized and export crops such as cotton, tobacco, and groundnuts were heavily taxed. In response to severe external shocks and resulting macroeconomic imbalances, Malawi embarked in 1981 on a series of structural adjustment and macroeconomic stabilization programs supported by donor organizations. The government adopted a flexible exchange rate policy, attempted to restructure its parastatals, and moved slowly toward liberalizing its price and marketing policies, especially in the agricultural sector. However, changes in agriculture were slowly implemented with improvements and setbacks until the early 1990s. It was not until April 1995 that all input and output prices were set free except for maize, although production and marketing of hybrid seed maize was liberalized. The maize policy together with the fertilizer subsidy continues to be the government's approach to the problem of food security in Malawi.

Table 10 presents the results of the analysis of structural change in the estimated TFP series of those countries contributing the most to TFP growth in SSA. In most cases the structural change coincides with the period of policy changes. The aggregated TFP series for SSA shows evidence of a break in the 1980s, which reflects the fact that the aggregated series is driven by Nigeria. When Nigeria is excluded, there is evidence of two breaks in the series: the first in 1984 and a second in the early 1990s when the second wave of changes and the devaluation of the CFA franc occurred. Considering individual countries, tests for Nigeria and Ghana show evidence that structural change occurred in the mid-1980s, when policy changes started. In Ivory Coast and Mali, structural change occurred in 1993–1994, coinciding with the CFA franc devaluation. There is evidence of structural change during the 1990s in East and Southern African countries, also coinciding with major policy changes in those countries: Ethiopia, Sudan, Tanzania, Malawi, and Mozambique.

Table 10. Test for structural change in estimated agricultural TFP series

		Additive outlier	Innovational outlier	Additive outlier	Innovational outlier
	Intercept and trend break	Sudden change in series	Gradual shift in the mean	Sudden change in series	Gradual shift in the mean
	zandrews	clemao1	clemio1	clemao2	clemio2
Nigeria		1985	1986		
Ghana					1968, 1982
Ethiopia					1974, 1995
Sudan				1976, 1990	1977, 1991
Ivory Coast				1973, 1994	1974, 1993
Cameroon	1968		1965		
Mali				1973, 1994	1974, 1995
Mozambique				1982, 1993	
Malawi				1970, 1990	1971, 1991
Kenya				1978, 1994	1966, 1979
Tanzania	1992	1999	2000		
SSA				1970, 1982	
SSA excluding Nigeria					1984, 1991

Source: Authors' estimations.
All values shown are significant at 5% level.
Note: The series were tested for two structural breaks using Clemente, Montañés, and Reyes's test for additive outliers, which captures a sudden change in a series (clemio2), or innovational outliers, allowing for a gradual shift in the mean of the series (clemao2). If these estimates show no evidence of a second break in the series, then zandrews, clemio1, and clemao1 are used assuming one structural break in the series (Baum 2001).

Significant Contribution of Technical Innovation to Improved Agricultural Performance

The improved performance of SSA's agriculture after 1985 is explained in part by structural adjustment and policy changes as discussed above. However, Block (1995) found that investment in R&D also contributes to explain productivity growth in SSA in the 1980s. There is recent evidence showing that R&D investment in the 1970s and 1980s has played a role in the recovery of SSA's agriculture.

The contribution to output growth in the 1980s and 1990s of cassava, maize, cotton, rice, and dairy, among other agricultural activities, is related to innovations that were the result of R&D investment and organizational changes that occurred in previous years. When these activities expanded under a new policy environment, they made a major contribution to the improved performance of the agricultural sector through improved allocation efficiency. The agricultural activities discussed here do not necessarily explain the largest share of TFP or output growth but are included because they incorporated new technologies and innovations in the production process. For instance, oil crops and other cereals show a significant contribution to output growth during the 1984–2003 period (18.7 percent, Table 3), but there is no evidence showing that this contribution is the result of technical change. In the case of groundnut production, it more than doubled between 1985 and 2003 with most of the increase being explained by area expansion that grew from 4.8 to 10.5 million hectares. Growth in other cereals (mainly sorghum and millet) can also be explained by area expansion. In the case of sorghum, the area harvested increased from 13 to 24 million hectares, while the harvested area of millet increased from 10 to 20 million hectares between 1983 and 2003. No significant improvement in yields of these crops can be found during this period (FAO 2007).

The most important of these innovations are presented as "successes in African agriculture" by Gabre-Madhin and Haggblade (2003) and a series of related papers. Of these successes and innovations, we highlight here those that appear to be related to the improvements in the performance of African agriculture in the 1980s and 1990s. We do this by summarizing information included in the mentioned studies analyzing successes in African agriculture: cassava (Haggblade and Zulu 2003; Nweke 2003; Gabre-Madhin and Haggblade 2003); maize (Smale and Jayne 2003; Gabre-Madhin and Haggblade 2003); cotton (Tefft 2003; Gabre-Madhin and Haggblade 2003); rice (Gabre-Madhin and Haggblade 2003); and dairy (Ngigi 2003).

The introduction of new varieties and modern disease-fighting research was behind the transformation of cassava production in Nigeria and Ghana. The new varieties were later introduced in other countries, and the area planted with cassava increased rapidly from 1984 to 2003 in several West African countries and some Southern African countries. For instance, in Mali and Guinea-Bissau, area under cassava increased at 14 percent per annum on average between 1984 and 2003. In Senegal, Ghana, Guinea, Nigeria, and Benin, the area planted with cassava grew at rates between 7 and 4 percent. In Southern Africa, Zambia, Zimbabwe, and Malawi substantially increased area planted with cassava (5.6, 3.9, and 3.7 per annum, respectively). Growth in yields during the same period was also high: 9.2 percent in Guinea-Bissau, 7.2 percent in Malawi, 5.4 percent in Chad, and above 2 percent in Benin and Senegal.

The impact of maize production in the surge of African agriculture after 1985 appears to be related to that crop's expansion in West Africa. In that region, research focused on small farmers, emphasizing improved yield and nutritional content of open-pollinating varieties instead of hybrids as was the case in the early development of maize production in East and Southern Africa. Although starting from a lower base than in other regions, maize growth in West Africa in the 1990s has been impressive. Between 1984 and 2003, maize area increased in Nigeria at an annual rate of 9.4 percent. In Mali and Chad, growth occurred at rates above 7 percent, while in Gabon, Burkina Faso, Gambia, and Togo, the area increased at rates above 4 percent per annum. Yields also increased in most countries at growth rates between 4 and 1.5 percent.

In the case of cotton, production in francophone West Africa combined a successful organization and coordination of the production chain with technical innovations (high-yield varieties, fertilizer use, access to equipment), becoming a successful generator of foreign exchange and fiscal revenues, higher income, and capitalization at the farm level. Benin increased area under cotton from 41,000 to 382,000 hectares in 20 years (11.8 percent per annum). Other West African countries also expanded land allocated to cotton production very rapidly between 1984 and 2003: Togo (9.6 percent), Burkina Faso (8.6 percent), Mali (8.1 percent), Cameroon and Ghana (5.6 percent), and Ivory Coast (4.25 percent).

The Africa Rice Center (WARDA) produced its first hybrids that combined the hardiness and wed suppression of African species with the high yields of the Asian varieties, which were incorporated to production by the end of the 1990s. Between 1994 and 2003, yields increased significantly in several West African countries: Benin (6.4 percent per year), Ivory Coast and Chad (5.1 percent), Togo (4.5 percent), Mauritania (3 percent), and Guinea (2 percent).

The Kenyan government's decontrol of milk pricing in 1992 spurred a surge in production and commercialization of milk in informal markets, which clearly benefited smallholders and small private processors. The surge in milk production and processing after market reforms was technically feasible because of the use of crossbred cows, a practice started during the colonial times and adopted by smallholder producers. By the early 2000s, 70 percent of Kenyan smallholders produced milk.

5. SUMMARY AND CONCLUSIONS

In this study we analyze the evolution of SSA's agricultural TFP in the past 40 years looking for evidence of recent changes in growth patterns using a nonparametric Malmquist index and its components, efficiency and technical change indices, for 30 Sub-Saharan African 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 check the TFP time series of all countries for structural change and relate those changes to the process of structural adjustment and policy changes in the 1980s and 1990s.

Results of our TFP estimates show a remarkable recovery in the performance of SSA's agriculture during the 1984–2003 period, after a long period of poor performance and decline. That recovery is significant not only compared with SSA's past poor performance but also when compared with TFP growth in Asia and Latin America. In the 10 years immediately after the region started implementing structural adjustment programs (1984–1993), TFP growth was driven mainly by only two countries: Nigeria and Ghana. Between 1994 and 2003, Nigeria and Ghana were still major contributors to TFP growth (53 percent), but now Sudan, Tanzania, Ethiopia, Cameroon, Mali, and Ivory Coast contributed close to 40 percent of SSA's total TFP growth.

Estimated TFP growth rates of individual countries show that Nigeria, with an average TFP growth rate of 4.6, was the most dynamic country from 1984 to 2003. With growth rates above 3 percent, Ghana and Benin also showed remarkable dynamism. Between 1994 and 2003, Chad, Tanzania, Nigeria, Mali, and Malawi had the best-performing agricultural sectors in terms of TFP growth. Sudan, Mozambique, Cameroon, and Ethiopia also improved their performance significantly during that period.

Accelerated TFP growth in SSA occurred simultaneously with rapid growth in output and changes in output composition. Rapid output growth after 1985 allowed SSA to increase agricultural output per capita, which had shown negative growth since the early 1970s. During the period of accelerated output growth, oil crops, roots and tubers, other cereals, pulses, and milk increased their share in total output while beef, tropical fruits, and traditional export crops reduced their participation in total output. The contribution to output growth of different crops and livestock products depends on the agro-ecological conditions and the production possibilities of the different regions. Roots and tubers were major contributors to output growth in all regions with the exception of the Sahel. Growth in oil crops also contributed significantly to growth in all regions. Traditional export crops and rice made the largest contribution to output growth in West Africa, while maize and livestock (beef and milk) had a major role in output growth in East Africa. Other cereals and sheep and goat meat were important in the Sahel and Sudan.

From the input side, the improved performance of agriculture in SSA during 1984 to 2003 can be related to an adjustment in the relative use of inputs in the production process. The most important change is an absolute reduction in the use of fertilizers at the aggregate level that hides different situations at the country level. Most of that reduction occurred between 1994 and 2003 and is explained by only five countries: Nigeria, Tanzania, Zambia, Zimbabwe, and Malawi. On the other hand, 21 countries in our sample increased the use of fertilizer. Ethiopia, Ivory Coast, Kenya, Benin, Cameroon, and Mali explain 80 percent of growth in fertilizer use between 1983 and 2003. The net effect from changes in these two groups of countries is the small reduction in fertilizer use verified at the aggregate level. Even though labor continues to increase faster than other factors, the use of fertilizer per worker and hectare of land increased in most of the best-performing countries.

Output growth and changes in the relative use of inputs resulted in a significant increase in output per hectare between 1984 and 2003, after several years of little or no growth. Output per worker also grew during that period, but that growth is more pronounced when Nigeria is included in the group of Sub-Saharan African countries. Considering TFP growth together with balanced growth in land and labor productivity as indicators of good agriculture performance, we find 12 countries (Nigeria, Ghana, Ivory

Coast, Burkina Faso, Mali, Mozambique, Malawi, Ethiopia, Sudan, Cameroon, Chad, and Congo) with relatively high TFP growth and sustained growth in labor and land productivity from 1994 to 2003. In most of those countries, growth in land and labor productivity can be explained by increased use of fertilizer per hectare and worker.

The evidence in this study points to policy change conducted by Sub-Saharan African countries between the mid-1980s and the second half of the 1990s as one of the many factors determining the agricultural sector's improved performance. First, a cross-section of Sub-Saharan African countries is used to regress TFP growth between 1994 and 2003 on a policy index measuring the implementation of structural adjustments in different Sub-Saharan African countries. The coefficient of the policy variable is positive and significant, showing a change in TFP performance of the agricultural sector, which might be partly attributed to improved macro and agricultural policies. Second, the analysis of structural change in the weighted-average SSA TFP series shows evidence of a break in the series in the mid-1980s. That coincides with the initial period of improved performance and TFP growth that runs from 1985 to 1993 driven mainly by early policy changes in Nigeria and Ghana. When Nigeria is excluded, there is evidence of two breaks (structural changes) in the aggregated SSA series: the first in 1984 and the second in the early 1990s coinciding with the devaluation of the CFA franc in West Africa and the end of internal conflicts and policy changes in East and Southern African countries. Third, most countries significantly contributing to TFP growth in SSA also show structural breaks in their TFP series in the mid-1980s, the 1990s, or both, coinciding with policy milestones and changes in those countries. Finally, policy changes coincide with a clear acceleration of agricultural output and GDP growth and increased exports and trade of agricultural products. The improved export performance is more remarkable if we consider that it occurred during a period of low international prices for SSA's exports. The improved performance of agriculture is not related exclusively to the export sector but reached also production for domestic markets given that production of staple crops also accelerated during the period of policy changes.

The favorable impact of policy change on agriculture found here does not disprove the criticism that has been aimed at structural policies in the long debate since their implementation in the mid-1980s. That criticism has had more to do with the failure of proposed macroeconomic policies to increase and diversify exports, attract investment, accelerate growth, and reduce inequality. The favorable impact of policy changes could be showing that policies applied by several Sub-Saharan African countries after independence imposed a heavy burden on agriculture, and that the structural adjustment implemented in the region brought a more favorable 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.

Although we did not formally evaluate the causal relationship between TFP growth and investment in R&D, there is evidence showing that policy changes facilitated the introduction of innovations in the production process. The contribution to output growth in the 1980s and 1990s of cassava, rice, export crops (cotton), maize (in West Africa), and dairy (in East Africa) are related to innovations that were the result of R&D investment and organizational changes that occurred in previous years. When the use of new technologies and innovations expanded under a new policy environment, they contributed significantly to the improved performance of the agricultural sector. One of the best examples of the contribution of innovations to TFP growth is the introduction of new varieties and modern disease-fighting research that transformed cassava production in Nigeria and Ghana and in the Southern African countries of Zambia, Zimbabwe, and Malawi.

Despite improved agricultural performance between 1985 and 2003, several signs still exist warning that SSA countries need to make more efforts to sustain TFP growth in the coming years. The decomposition of TFP growth into efficiency and technical change shows that most TFP growth in the last 20 years is the result of SSA catching up to the frontier after falling behind during the 1964–1983 period. This structure of TFP growth in SSA differs substantially from that of other regions, where a significant share of TFP growth is explained by technical change. With a small contribution of technical change to TFP, we expect growth 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 countries leading the recovery of SSA's agriculture in the mid-1980s.

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 reduces in the coming years, yields will need to increase faster to compensate for growth in rural population and improve rural income. Increased and sustained TFP and labor productivity growth in the future will be possible only if policy improvements are complemented by investments that accelerate the expansion of SSA's technical frontier.

APPENDIX A: IMPLICIT INPUT SHADOW SHARES

Two main problems were found with shadow prices when estimating the distance functions. First, shadow prices do not correspond with the importance of the different inputs in agricultural production. Table A.1 shows the average estimated unconstrained shadow input shares for Sub-Saharan African countries for the period 1964–2003. Labor has the largest share on average for the group of countries considered here (0.37), followed by land (0.30), tractors (0.14), animal stock (0.11), and fertilizer (0.08). These input share values are calculated as the simple average of the individual country input shares in different periods. The shares of tractors and fertilizers appear to be too high for Sub-Saharan African countries, given the small number of tractors and the very low use of fertilizer in agriculture production. The comparison of these values with those estimated by Evenson and Dias Avila (2007) confirms this. For those authors, the maximum share for "mechanization" among Sub-Saharan African countries is 10 percent (Botswana). The share of fertilizer as estimated by Evenson and Dias Avila is also smaller than the unconstrained DEA estimates we obtained, with their maximum estimate being 9 percent (Congo). On the other hand, the unconstrained DEA estimates of land and labor shares are smaller than those obtained by Evenson and Dias Avila (30 and 37 percent on average compared with 58 and 48 percent, respectively)

The second problem with the unconstrained DEA shadow shares is the incidence of zero shadow prices. We show the incidence of zero input prices in Table A.2. The number of zero shadow prices is very high for animal stock and also very important for land and labor. For instance, in the cases of Botswana, Swaziland, and Zimbabwe, animal stock is never included as an input in TFP growth estimates, and it is not considered in TFP estimations in 98 percent of the years for several countries. Land, labor, and tractors also appear to have a high incidence of zero shadow prices. This means that with unconstrained shadow prices, agricultural efficiency and productivity changes are measured without bringing into consideration the use of animal stock, land, or labor at least in one year in most Sub-Saharan African countries. The incidence of zero shadow prices of relevant inputs justifies the introduction of constraints to shadow prices in order to ensure that all relevant inputs are included in the estimation of efficiency and productivity indices.

To define the bounds for the input shares we introduce information on the likely value of the shares of the different inputs from the referenced paper by Evenson and Dias Avila (2007). These bounds are presented in Table A.3, and average input shares for Sub-Saharan African countries resulting from the constrained estimation of distance functions using linear programming are shown in Table A.4. Figure A.1 compares cumulative Malmquist indexes obtained with unconstrained and constrained shadow prices.

As shown by the figure, both constrained and unconstrained TFP estimates follow the same trend. However, if our assumptions about input share values are correct, then the unconstrained approach would be overestimating productivity growth in Sub-Saharan African countries. For the whole period, the average annual growth rate for the region with unconstrained estimates is 0.15, compared with –0.07 in the constrained case. That is a difference of 20 percent in the annual growth rate. However, the constrained and unconstrained approaches could result in very different estimates for some countries. Table A5 shows estimates by country and the differences sorted by the importance of the difference in estimates relative to the unconstrained estimates. For nine of these countries, the difference between estimates represents more than 50 percent of the annual TFP growth rate obtained with unconstrained shadow shares. In the case of Tanzania, the unconstrained measure results in an estimated 26 percent TFP growth in 20 years, while the constrained measure indicates twice as much growth (53 percent). Other countries show similar or larger differences in TFP growth.

Table A.1. Unconstrained shadow shares, average, 1964–2003

	Animal stock	Fertilizer	Labor	Land	Tractors	Total
Benin	0.02	0.06	0.57	0.16	0.19	1.00
Botswana	0.00	0.14	0.07	0.76	0.03	1.00
Burkina Faso	0.00	0.06	0.57	0.22	0.15	1.00
Cameroon	0.06	0.06	0.68	0.02	0.18	1.00
Chad	0.00	0.06	0.63	0.15	0.16	1.00
Congo, Rep.	0.70	0.08	0.11	0.10	0.01	1.00
Ivory Coast	0.24	0.05	0.43	0.08	0.20	1.00
Ethiopia	0.00	0.05	0.49	0.38	0.08	1.00
Gabon	0.45	0.12	0.40	0.02	0.01	1.00
Gambia	0.00	0.04	0.41	0.50	0.06	1.00
Ghana	0.29	0.10	0.35	0.13	0.14	1.00
Guinea	0.00	0.02	0.61	0.29	0.08	1.00
Guinea-Bissau	0.00	0.02	0.72	0.14	0.12	1.00
Kenya	0.00	0.07	0.16	0.55	0.22	1.00
Lesotho	0.02	0.24	0.17	0.47	0.10	1.00
Madagascar	0.00	0.04	0.35	0.47	0.15	1.00
Malawi	0.41	0.05	0.23	0.22	0.09	1.00
Mali	0.00	0.06	0.43	0.40	0.10	1.00
Mauritania	0.00	0.04	0.33	0.54	0.08	1.00
Mauritius	0.12	0.08	0.32	0.14	0.34	1.00
Mozambique	0.52	0.06	0.03	0.36	0.03	1.00
Nigeria	0.14	0.04	0.54	0.08	0.20	1.00
Senegal	0.03	0.04	0.46	0.25	0.22	1.00
Sudan	0.08	0.09	0.36	0.24	0.23	1.00
Swaziland	0.00	0.36	0.03	0.52	0.09	1.00
Tanzania	0.00	0.11	0.00	0.88	0.00	1.00
Togo	0.08	0.08	0.72	0.00	0.12	1.00
Zambia	0.13	0.06	0.40	0.06	0.35	1.00
Zimbabwe	0.00	0.20	0.08	0.49	0.23	1.00
Average	0.11	0.08	0.37	0.30	0.14	1.00

Table A.2. Percentage of zero shadow prices in 1964–2003 for Sub-Saharan African countries

	Animal stock	Fertilizer	Labor	Land	Tractors
Benin	42	0	0	12	0
Botswana	100	0	0	0	91
Burkina Faso	98	0	2	7	2
Cameroon	28	0	0	65	0
Chad	98	0	0	2	0
Congo, Rep.	0	2	19	14	74
Ivory Coast	0	5	0	60	7
Ethiopia	77	0	0	0	0
Gabon	0	0	2	91	93
Gambia	98	0	12	0	0
Ghana	0	0	0	28	16
Guinea	98	0	0	0	0
Guinea-Bissau	79	0	0	0	0
Kenya	98	0	28	0	2
Lesotho	81	0	0	5	47
Madagascar	95	0	0	0	0
Malawi	0	0	37	0	0
Mali	86	0	0	2	2
Mauritania	88	0	16	0	14
Mauritius	14	58	12	58	14
Mozambique	0	0	77	0	70
Nigeria	0	0	0	67	0
Senegal	37	0	0	0	0
Sudan	56	0	0	51	0
Swaziland	100	0	26	0	42
Tanzania	84	0	88	0	88
Togo	16	0	0	100	5
Zambia	0	0	0	65	0
Zimbabwe	100	0	7	0	7
Average	54	2	11	22	20

Note: Distance functions are calculated for each country and each year to estimate TFP growth. A value of 100 in the table means that the estimated shadow price for the input was zero for all years in the period 1964–2003; a value of 50 means that it was zero for half of the years; and so forth.

Table A.3. Upper and lower bounds for shadow shares used in the constrained linear programming DEA problems to estimate distance

	Upper bound	Lower bound
Land	0.72	0.32
Labor	0.52	0.25
Animal stock	0.32	0.07
Tractors	0.10	0.0001
Fertilizer	0.10	0.0001

Table A.4. Constrained shadow shares, average, 1964–2003

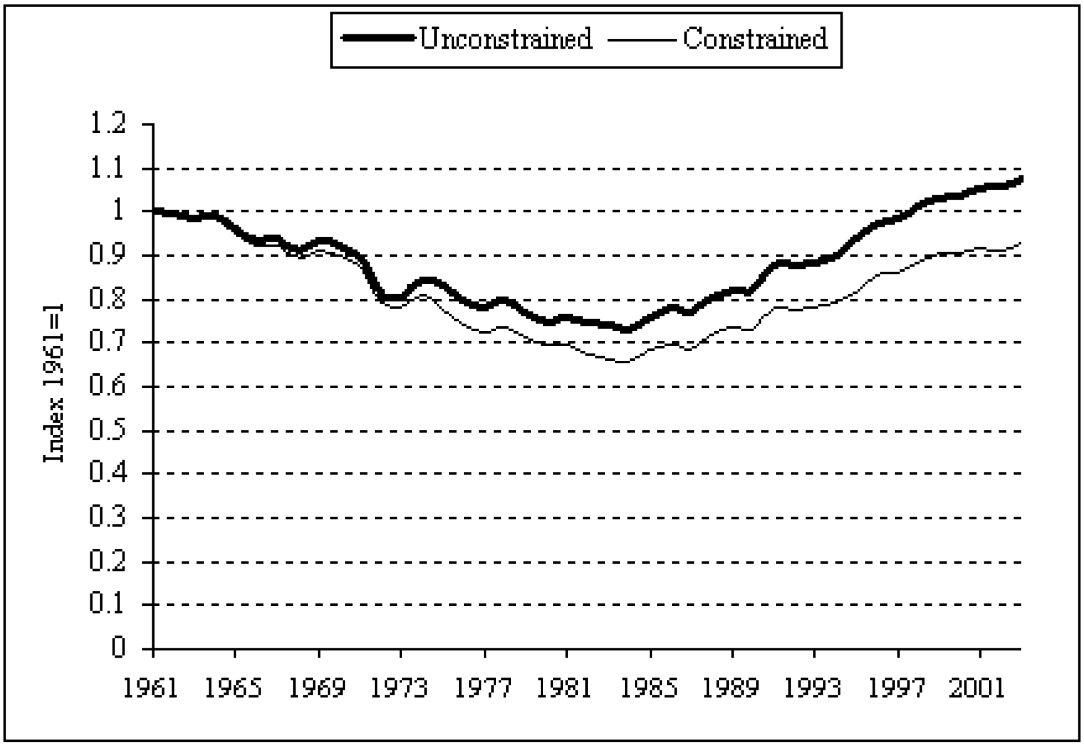
	Animal stock	Fertilizer	Labor	Land	Tractors	Total
Benin	0.08	0.04	0.45	0.36	0.08	1.00
Botswana	0.07	0.10	0.25	0.56	0.02	1.00
Burk. Faso	0.09	0.03	0.40	0.38	0.10	1.00
Cameroon	0.09	0.06	0.45	0.32	0.08	1.00
Chad	0.07	0.06	0.42	0.35	0.09	1.00
Congo, Rep.	0.31	0.05	0.26	0.32	0.07	1.00
Ivory Coast	0.29	0.05	0.25	0.32	0.10	1.00
Ethiopia	0.07	0.06	0.36	0.42	0.10	1.00
Gabon	0.26	0.09	0.32	0.32	0.01	1.00
Gambia	0.08	0.05	0.28	0.50	0.10	1.00
Ghana	0.24	0.07	0.27	0.32	0.10	1.00
Guinea	0.08	0.04	0.26	0.54	0.07	1.00
Guinea-Biss.	0.07	0.02	0.50	0.32	0.08	1.00
Kenya	0.08	0.05	0.25	0.52	0.10	1.00
Lesotho	0.08	0.08	0.25	0.51	0.08	1.00
Madagascar	0.07	0.09	0.25	0.48	0.10	1.00
Malawi	0.19	0.06	0.26	0.39	0.10	1.00
Mali	0.07	0.05	0.29	0.50	0.09	1.00
Mauritania	0.08	0.05	0.27	0.52	0.08	1.00
Mauritius	0.13	0.04	0.38	0.39	0.06	1.00
Mozambique	0.28	0.05	0.25	0.32	0.10	1.00
Nigeria	0.20	0.05	0.30	0.36	0.09	1.00
Senegal	0.14	0.05	0.36	0.35	0.10	1.00
Sierra Leone	0.09	0.04	0.25	0.54	0.07	1.00
Sudan	0.09	0.08	0.33	0.41	0.10	1.00
Swaziland	0.11	0.07	0.25	0.49	0.08	1.00
Tanzania	0.08	0.06	0.25	0.54	0.07	1.00
Togo	0.12	0.03	0.46	0.32	0.07	1.00
Zambia	0.29	0.04	0.25	0.32	0.10	1.00
Zimbabwe	0.09	0.06	0.25	0.54	0.06	1.00
Average	0.13	0.05	0.31	0.42	0.08	1.00

Table A.5. Annual growth rates estimated with constrained and unconstrained shadow shares

	Unconstrained	Constrained	Abs diff	Ratio diff[a]
Madagascar	-0.34	0.43	0.77	2.24
Congo, Rep	0.27	0.81	0.54	2.02
Mauritania	-0.49	-1.12	0.63	1.28
Tanzania	1.16	2.15	0.99	0.86
Botswana	-0.68	-1.18	0.49	0.72
Guinea	0.81	0.31	0.50	0.62
Ethiopia	0.46	0.71	0.25	0.53
Lesotho	-2.30	-1.09	1.20	0.52
Mali	1.15	0.56	0.59	0.51
Ivory Coast	1.76	0.99	0.77	0.44
Zimbabwe	1.41	0.81	0.61	0.43
Zambia	1.11	1.49	0.38	0.34
Gambia	-1.65	-1.20	0.45	0.27
Gabon	1.32	1.61	0.29	0.22
Kenya	1.15	1.38	0.23	0.20
Burkina	1.14	0.91	0.23	0.20
Swaziland	-0.18	-0.22	0.03	0.19
Chad	1.33	1.14	0.19	0.14
Sudan	1.18	1.34	0.16	0.14
Mozambique	1.07	1.21	0.14	0.13
Nigeria	3.59	3.15	0.43	0.12
Mauritius	1.76	1.56	0.20	0.11
Guinea-Biss	1.03	0.93	0.10	0.10
Ghana	4.19	4.52	0.33	0.08
Benin	3.80	3.51	0.29	0.08
Malawi	2.02	2.13	0.11	0.05
Senegal	0.56	0.53	0.03	0.05
Cameroon	1.63	1.68	0.05	0.03
Togo	1.82	1.78	0.04	0.02

[a] Ratio of the absolute difference and the unconstrained estimates.

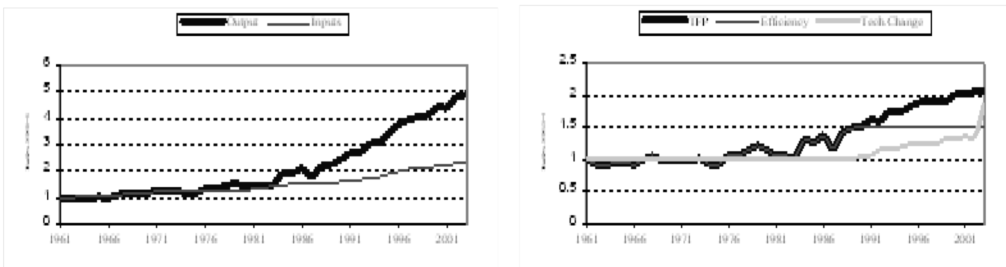
Figure A.1. Cumulative Malmquist index estimated with unconstrained and constrained shadow prices



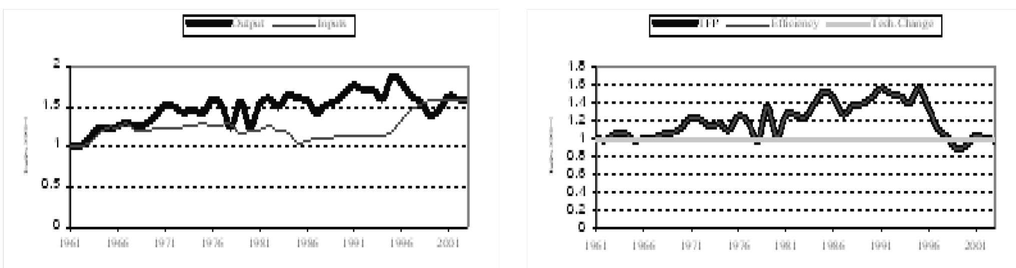
APPENDIX B: AGRICULTURAL OUTPUT, INPUTS, AND TFP TRENDS IN SUB-SAHARAN AFRICAN COUNTRIES

Figure B.1. Cumulative agricultural output, inputs, TFP, efficiency, and technical change indices for Sub-Saharan African countries, 1961–2003 (1961 = 1)

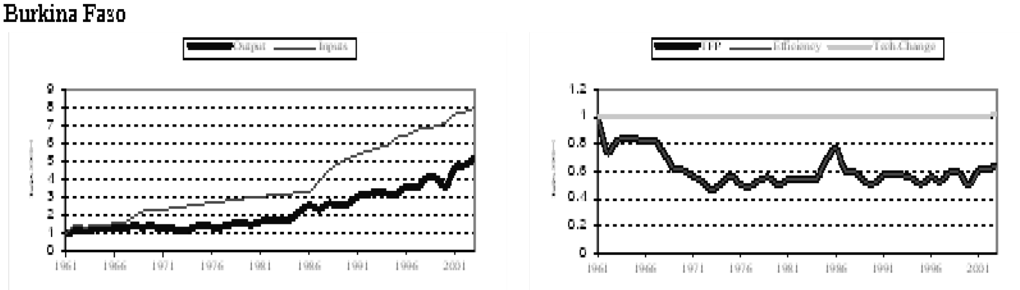
Benin



Botswana



Burkina Faso



Cameroon

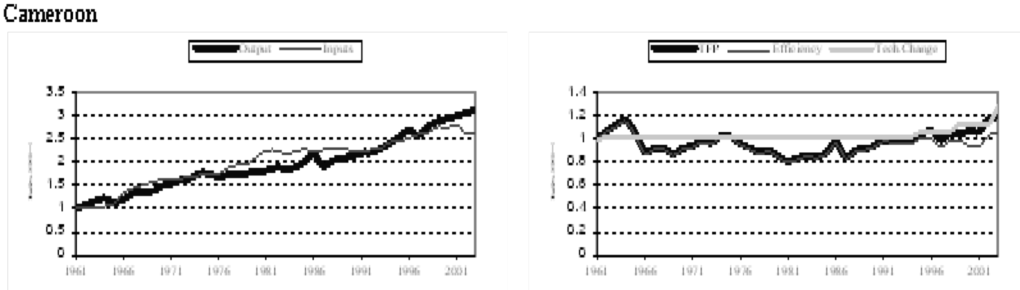
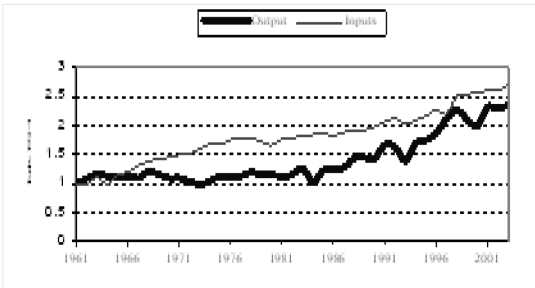
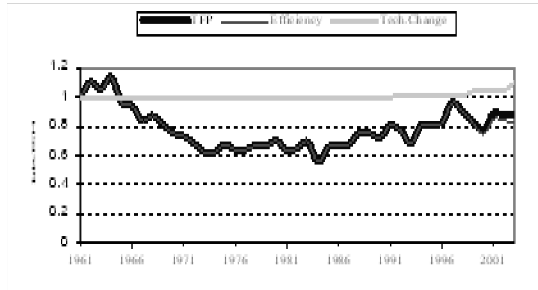


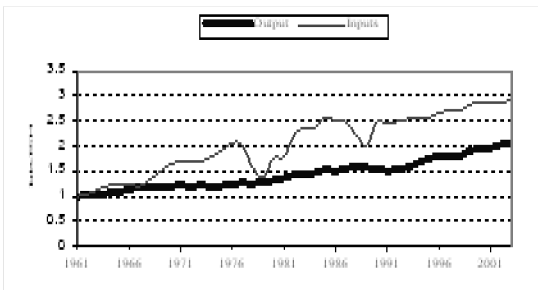
Figure B.1. Continued

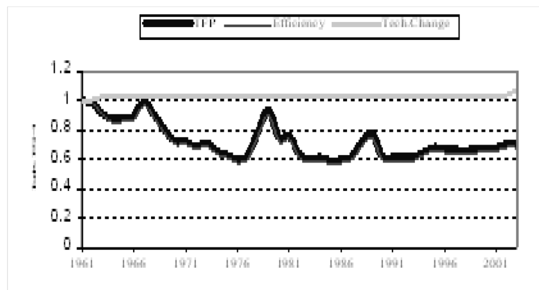
Chad



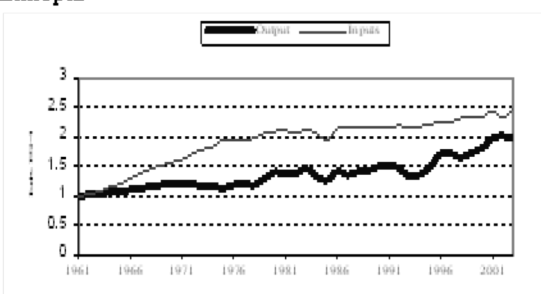


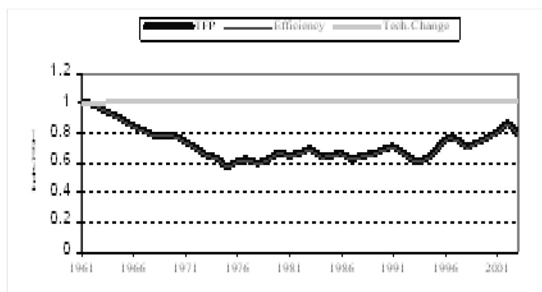
Congo, Republic



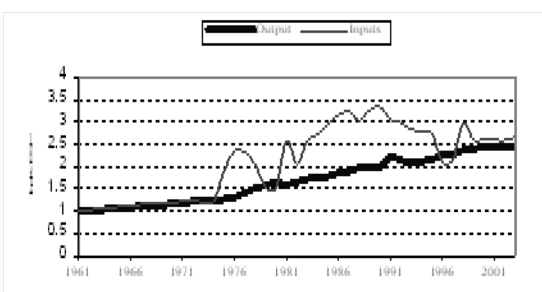


Ethiopia





Gabon



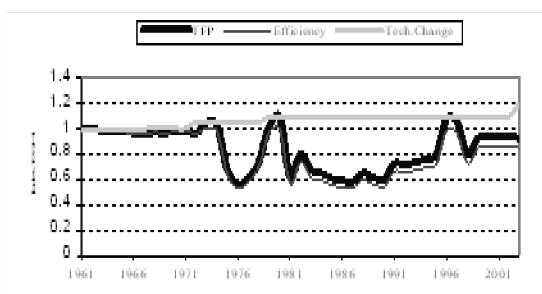
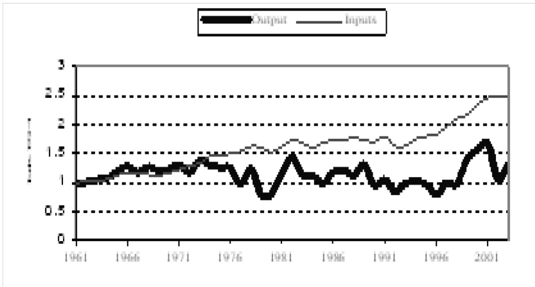
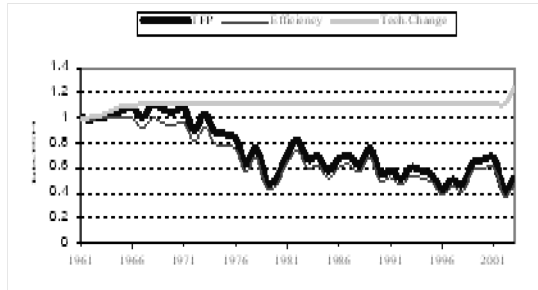


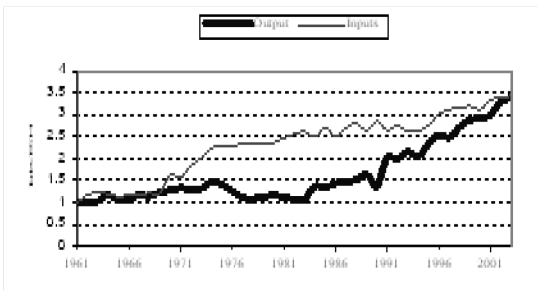
Figure B.1. Continued

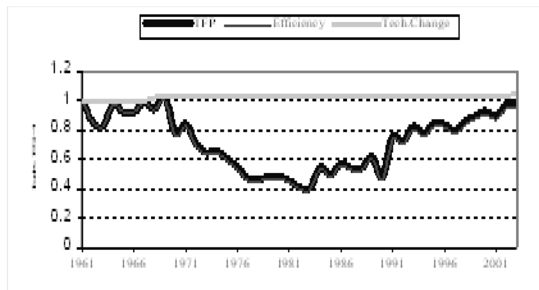
Gambia



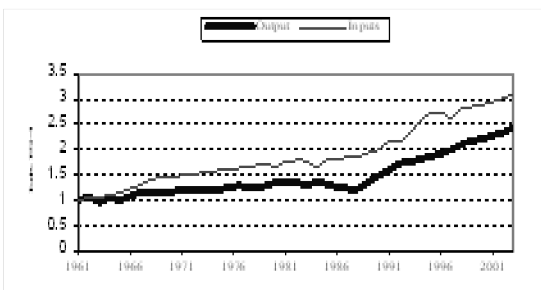


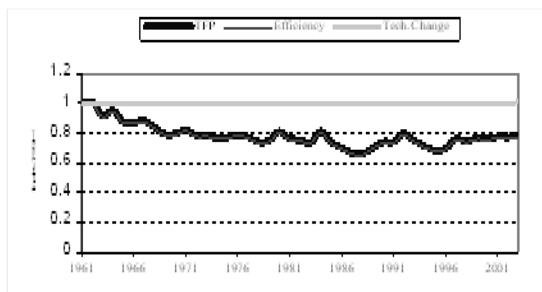
Ghana



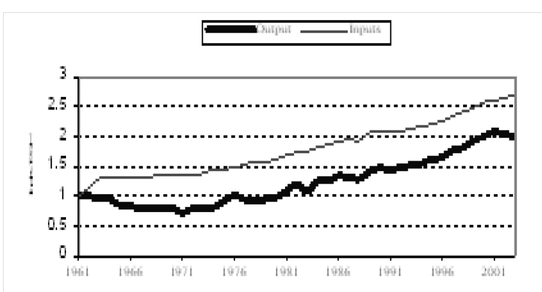


Guinea





Guinea-Bissau



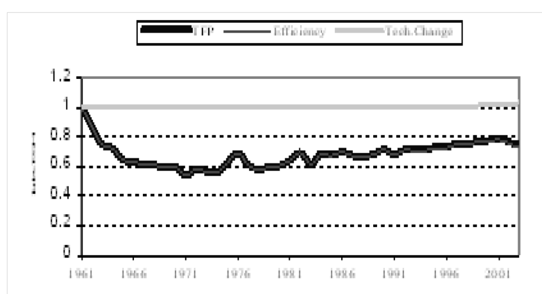
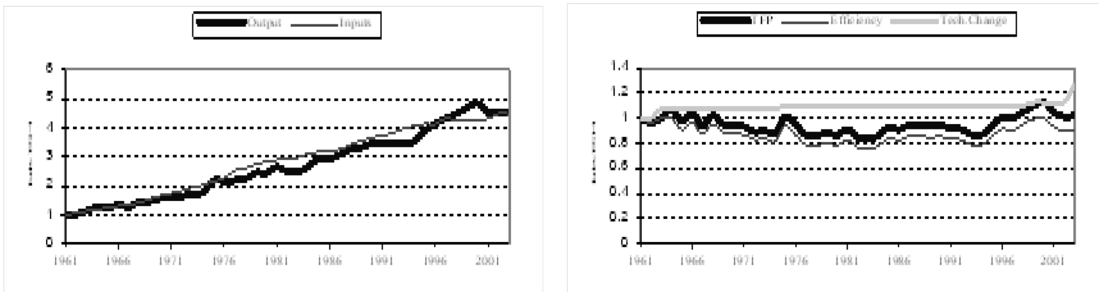
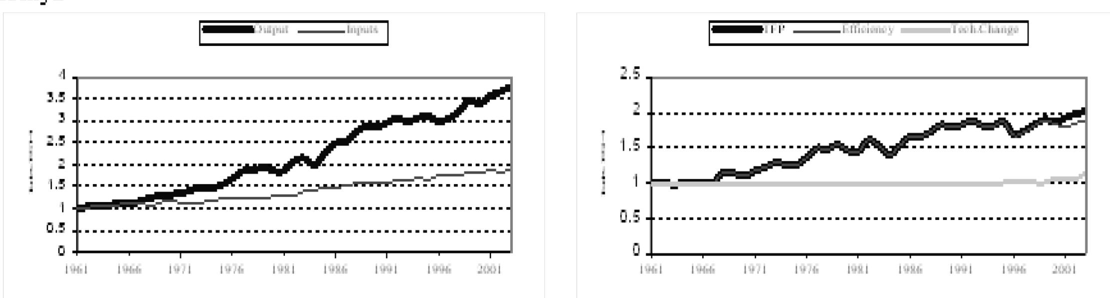


Figure B.1. Continued

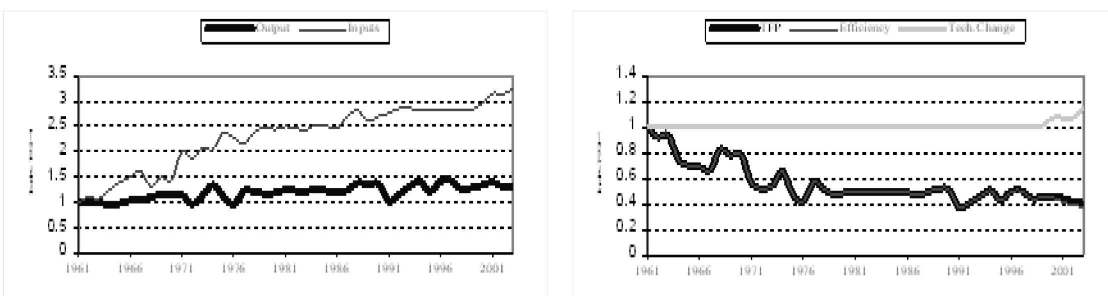
Ivory Coast



Kenya



Lesotho



Madagascar

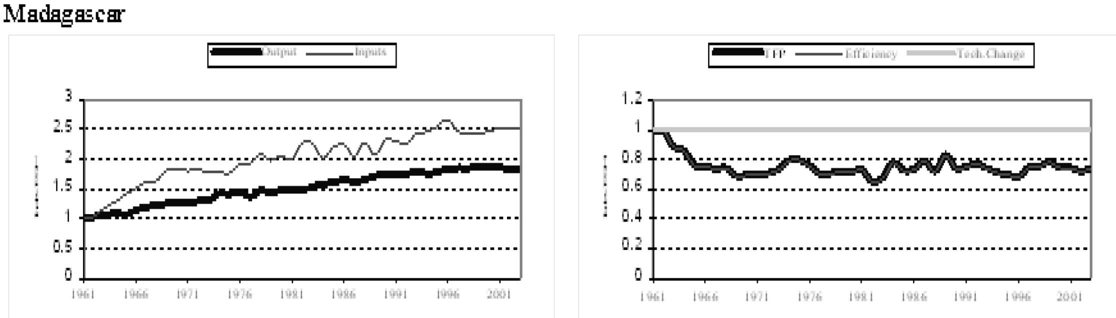
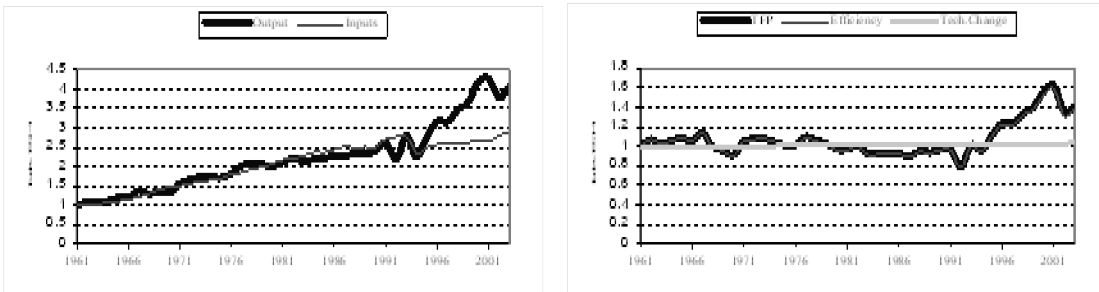
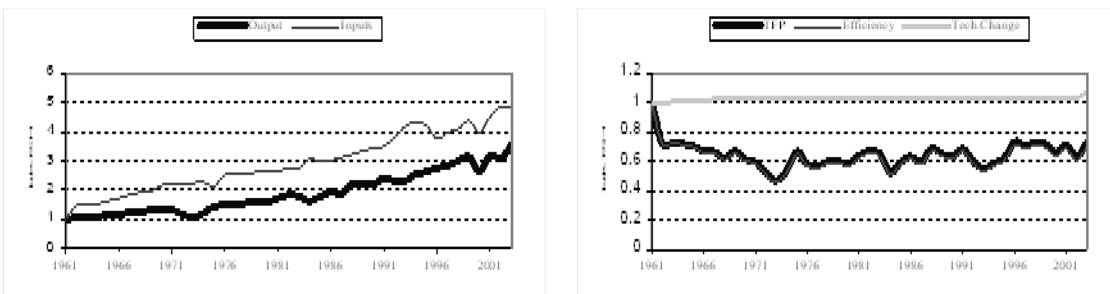


Figure B.1. Continued

Malawi



Mali



Mauritania

Mauritius

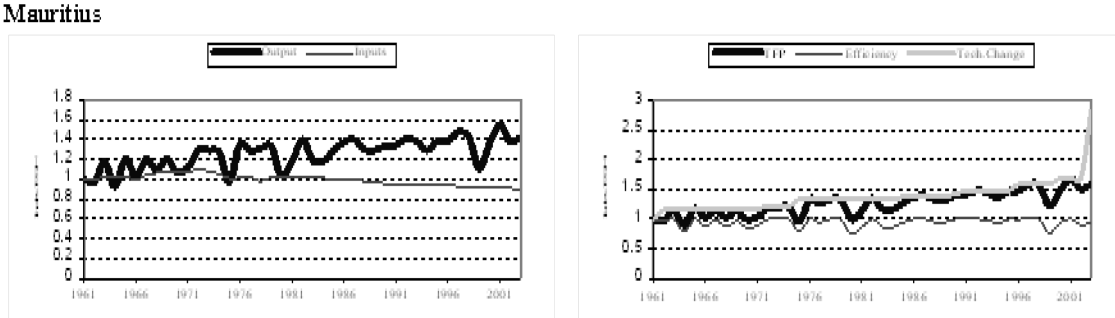
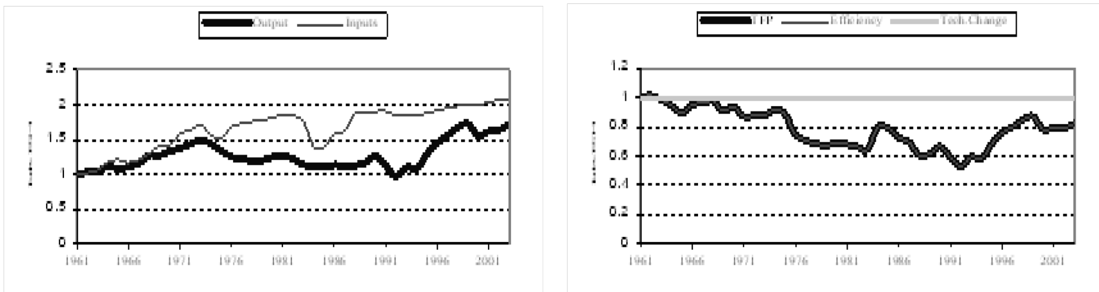


Figure B.1. Continued

Mozambique



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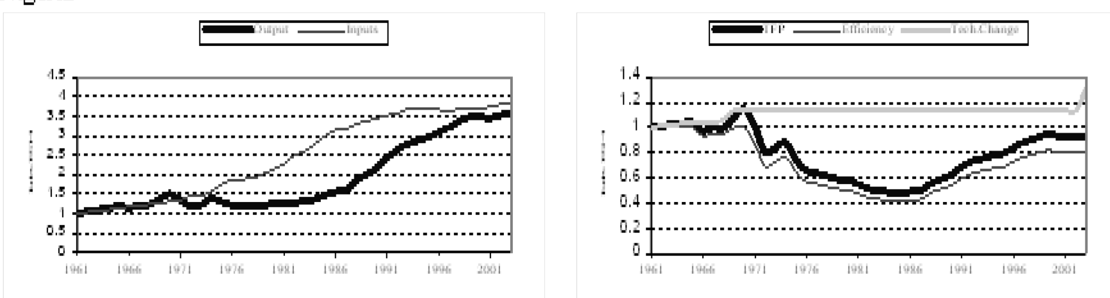

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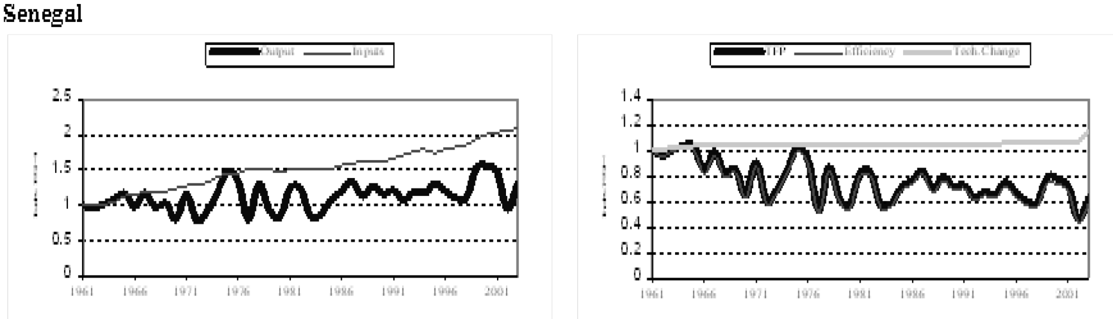

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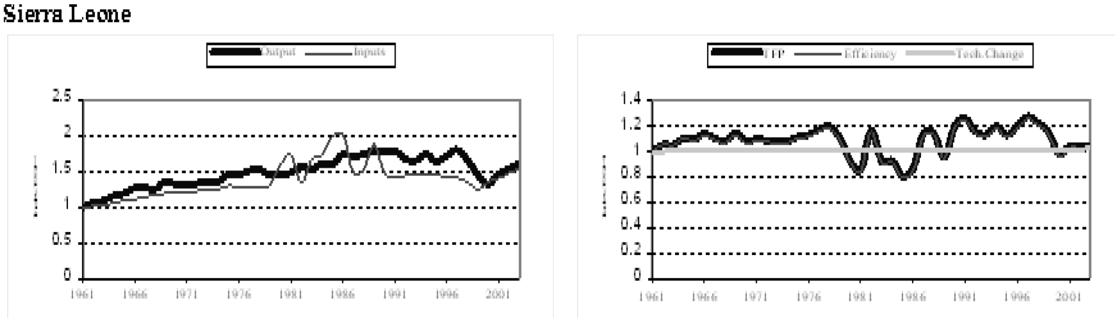
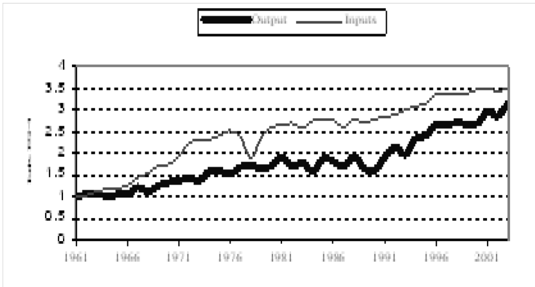
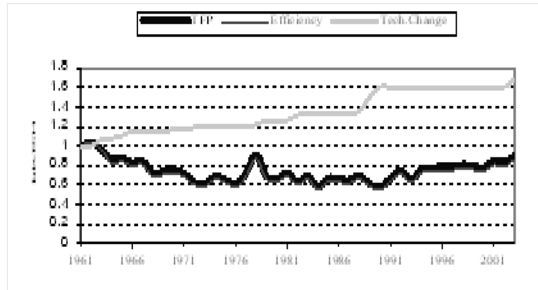


Figure B.1. Continued

Sudan





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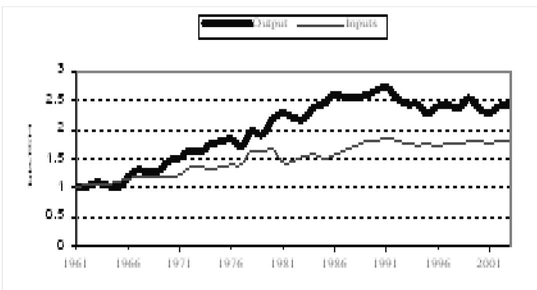
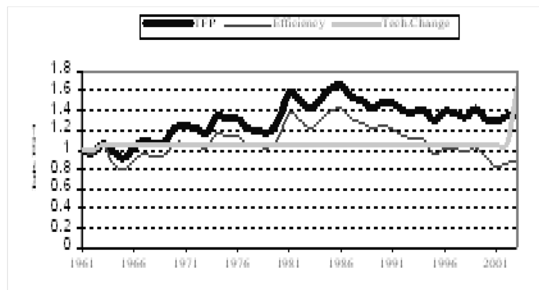
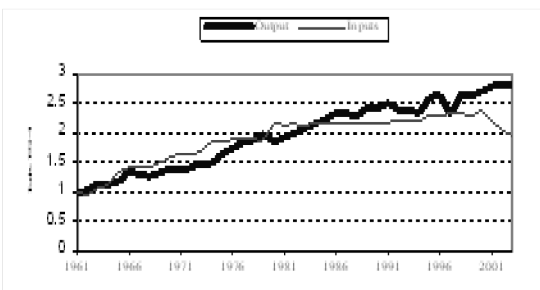
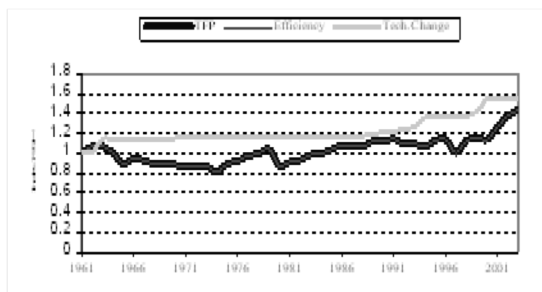




Tanzania





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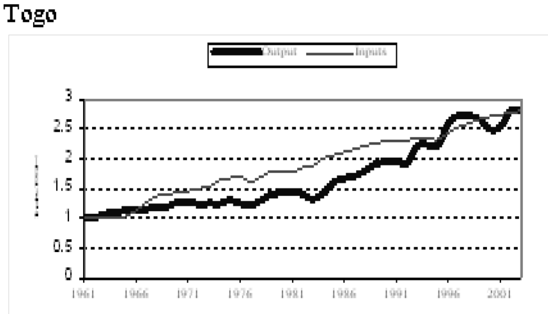


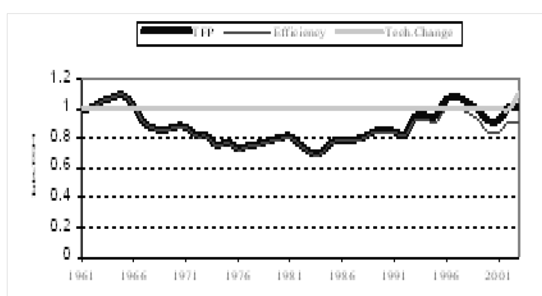
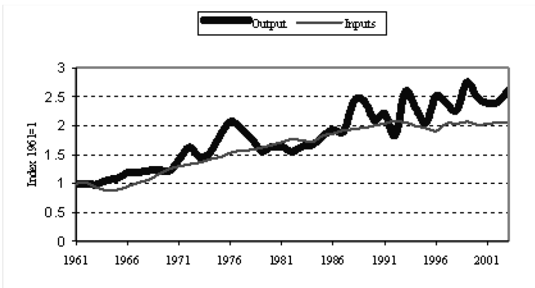
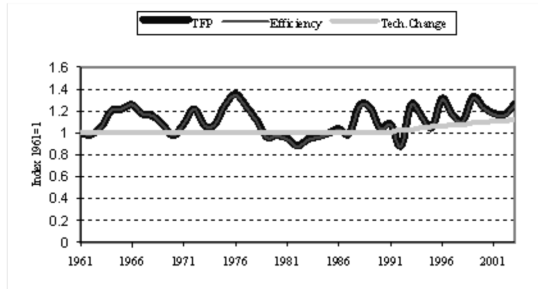


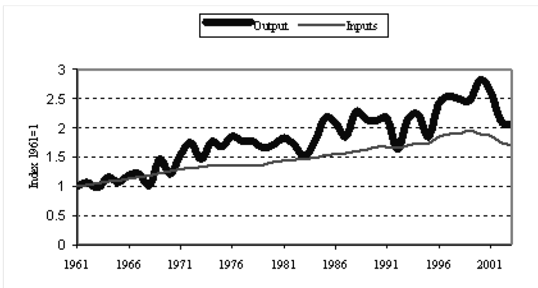
Figure B.1. Continued

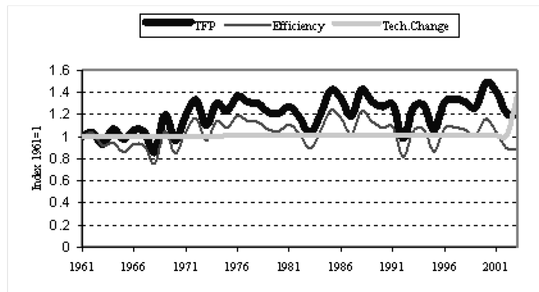
Zambia





Zimbabwe





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