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Remittances and Agricultural Technical Efficiency in Africa: Panel Data Analysis

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Abstract

The paper examines the impact of international remittances on agricultural technical efficiency across 34 African countries and 31 years panel data. To estimate the stochastic production frontier three classical production inputs and eleven technical efficiency (excluding time dummies) variables are included in our analysis. All inputs variables found to be highly significant. While the covariates in the inefficiency estimation, such as, mobile and private credit found to be against our expectations, and the rest were consistent and highly significant. Especially, the variable of our interest, international remittances tend to show a U-shape, with first order variable being positive and negative in the second order (both significant at 1% level). Regional as well as time dummies are also very consistent and most of significant. Hence, to improve the utilization of remittance and channel the resource to productive purpose more governmental effort in educating remittance recipients seems necessary.

Keywords: *Remittances, Agricultural Technical Efficiency, Panel Data Analysis.*

1. Introduction

In 2021, 52 per cent of employed people in Sub-Saharan Africa were active in agriculture, and about 45 per cent of the world's area suitable for sustainable agriculture production expansion is located in Africa (Akiwumi, 2022). Agriculture in Africa has a massive social and economic footprint as over 60 per cent of sub-Saharan Africans are smallholder farmers, and about 23 per cent of sub-Saharan Africa's GDP comes from agriculture (Goedde et al., 2019). Given the sector's large contribution to the overall economy, its substantial indirect impact on growth in other sectors, and the extent to which poor people participate in the sector, agriculture's role remains indispensable in fighting poverty (The World Bank, 2007). The current development thinking, both at the international forum and African Development Agenda, (Millennium Development, Sustainable Development by 2030 and Africa Agenda 2063) focuses on poverty reduction rather than economic growth per se. Hence, a robust agricultural growth is a key factor to address the pervasive poverty and food insecurity in Sub-Saharan Africa (SSA).

Significant investment will be required to realize Africa's full agricultural potential and to promote growth. Sub-Saharan Africa will need eight times more fertilizer, six times more improved seed, at least $8 billion of investment in basic storage and as much as $65 billion in irrigation to fulfill its agricultural promise (Goedde et al., 2019). Government

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spending on agriculture would go a long way in terms expanding the sector and creating more value.

In the past decade, a new momentum has emerged to transform African agriculture, driven by national governments and multilateral institutions, such as specialized civil society organizations like the Alliance for a Green Revolution in Africa (AGRA), the United Nations' Consultative Group on International Agricultural Research (CGIAR) and others (Africa Progress Panel, 2010). According to FAO, gross agricultural production in Sub-Saharan Africa (SSA) grew at an average annual rate of 2.6 per cent between 1961 and 2008. Since 1991, agricultural growth has been higher at 3.1 percent per year. According to (FAO, 2021), value added generated by agriculture, forestry and fishing in Africa grew from US$170 billion in 2000 TO US$404 billion in 2019. However, when we compare the growth of SSA's, agricultural production with the population growth rate (nearly 2.7 percent per annum) of the same period, and the growth rate in food production per person in Asia, Africa's food production per person barely improved at all (Africa Progress Panel, 2010). Hence, the poor performance of the agricultural sector explains much of the slow progress towards reducing poverty and hunger in Africa. According to the 2022 Global Report on Food Crises 2022 mid-year update by (Global Network Against Food Crises, 2022), at least one in five Africans goes to bed hungry and an estimated 140 million people in Africa face acute food insecurity. African agriculture's historically poor performance might reflect long-term underinvestment in Research and Development, poor infrastructure, poor agricultural and macroeconomic policies (such as, credit constraint, low pricing of agricultural commodities, etc.), and lack of political stability rather than the growth potential of the sector (Block, 2014).

Against these backdrops, African Head of States came up with a new initiative called The New Partnership for Africa's Development (NEPAD), which was adopted in 2003 in Maputo whereby states pledged to devote at least 10% of national budgets to agriculture in order to raise agricultural growth to 6% a year, a rate needed to reduce poverty by half. NEPAD focus on key pro-poor sectors, such as, health, education, infrastructure and agriculture. Recognizing the role of agriculture for the alleviation of poverty and hunger, NEPAD in collaboration with FAO developed the Comprehensive Africa Agriculture Development Programme (CAADP). In response to the NEPAD and CAAP initiatives, some African countries have shown a great interest in Agriculture in terms of government expenditure on agriculture, e.g. Mali (9.2 per cent), Eswatini (5 per cent) and Botswana (4.4 per cent) of government total expenditure allocated to agriculture, forestry and fishing in 2019 while Malawi (16 per cent), Togo (8 per cent) and Zambia (7 per cent) allocation in 2017 (FAO, 2021). This is a great interest as majority of the countries worldwide allocated less than 3.5 per cent between 2017 and 2019.

As part of the NEPAD and CAAP initiatives, some African countries have shown interest to improve the production of certain agricultural products that directly reduce hunger. The Ugandan government has prioritized maize production due to its high potential for creating food security given unreliable rains and adverse weather (Kinuthia, 2020). In 2016, the Ugandan government distributed 14.6 million bags of maize seeds to both commercial and small-scale farmers with the hopes to produce 10 million tons by 2020 and export $105 million (Kinuthia, 2020). While several countries have increased the share of total spending allocated to the agriculture sector, comparing the pre-CAADP (1995–2003) and post-CAADP (2003–2010) periods, only a handful of countries achieved the target resulting in the low performance seen for Africa as a whole. This means agriculture is under-financed in terms of extension services, credit for inputs, research support, etc.

On the other hand, one strategy of escaping poverty that Africans employ is migration. Its scale has risen with almost 4% of the total African population or 31 million international migrants. Concomitantly, there is an increase in the amount of remittances leading some scholars questioning the effects of this migration on agriculture (Castles and Miller, 1998; Mohapatra and Ratha, 2011).

There are few empirical works both at macro and micro level studies that have been undertaken on the impact of migration on agriculture. Using two surveys performed in the Senegal River valley, in Mali and in Senegal, Azam and Gubert (2006) found that remittances helped to smooth household consumption during adverse shocks. They also found this insurance system involved some moral hazard, as those remaining behind tend to exert less effort to take care of themselves, knowing that the migrants will compensate any consumption shortfall.

Using cross country macro data (sample countries drawn from Latin America, Asia, Europe, Middle East and North Africa), Taylor (1996) reported a dynamic role international migration could play in promoting economic growth and national development in a given economy, provided that it does not bring the selective emigration of scarce human capital. Abduvaliev and Bustillo (2020) examine the long-run relationship between migrant remittances and economic growth in 10 Commonwealth of Independent States (CIS). The results indicate that on average, a 1% increase in remittance flows provokes around a 0.25% rise in per capita GDP and a 2% decline in poverty severity. Oshota and Badejo (2015) examined the long-run relationship between remittances and economic growth in Nigeria for the period 1981-2011. The result indicates that remittances positively affect the economic growth of Nigeria in the long-run; one percent increase in remittances would lead to 0.19 percent increase in the country's economic growth in the long-run. Furthermore, Saidu and Salisu (2020) investigated the same issue in SSA between 1980 and 2018. The authors report that an increase in remittances, foreign direct investment, trade openness and domestic investment, increases economic growth in SSA.

Analyzing the impact of remittances on poverty using cross sectional data from 71 developing countries, Adams and Page (2005) found that10 % increase in the share of international migrants in a country's population helps to reduce by 2.1% people living on less than $1 per person per day. A paper studying the effect of remittance on poverty and financial development in Sub-Saharan Africa finds that remittances being stable private transfers have a direct poverty-mitigating effect (Gupta et al., 2009). Adams (1991) found that in rural Egypt, the number of poor households declined by 9.8% when household income included international remittances, and that remittances accounted for 14.7% of total income of poor households. According to proponents (Ajefu and Ogebe, 2020), remittances significantly support household consumption and reduce poverty.

In their study on how labour migration affects farm technical efficiency in Lesotho, Mochebelele and Winter-Nelson, (2000) found a slightly greater technical inefficiency among non-migrant households, implying that they are at some disadvantage in their ability to apply the resources that they allocate to farming. Hence, remittances do positively help to follow a consistent and timely farm management than those without migrants among their household members. Mendola (2008) who examined how migration and technical change interact in rural households in Bangladesh found that households who are able to engage in costly high-return migration (i.e. international migration) are more likely to employ modern farming technology, thereby achieving higher productivity. Nonthakot and Villano (2009) examine the impact of labour migration on farm efficiency in northern Thailand and found that remittances, duration of migration enhance the productive capacity of maize farmers.

However, according to some other literature, migration decreases farm efficiency. Sauer et al. (2015) investigates the effect of migration on farm technical efficiency drawing on a large and representative sample of agricultural households in Kosovo. According to the study, migration has an efficiency decreasing effect, which is amplified for better educated workers. Eshetu et al. (2020) examine the impact of rural out-migration on the technical efficiency of producers and found that rural out-migration significantly reduces crop technical efficiency. Diallo (2020) examine the effects of migration and remittances on agriculture in Senegal. According to the study, the departure of a member of the household negatively impacts on agricultural productivity. Similarly, Ren et al. (2023) study suggests that migration has a marginally negative impact on both technical efficiency and fertilizer use efficiency of their rice production, while the impact is amplified for farmers who participated in migration more intensively. This literature appears to support the lost labour hypothesis of the new economics labor migration theory. With increasing interest in migration and deteriorating economies in migrants' sending countries, it is obvious that farming technical skills in youths is lost. The more migration gains in the form of remittances, the more the tendency for migrants to move away from farming. It is important to note the migrants leave farming to migrate because they find farming unsustainable. This insinuates that they may see no need to invest their gains from migration in farming, even though their farms may produce well with higher capital supply.

Control to the lost labour hypothesis, it has been reported that earnings of international migrants to have a positive impact on crop productivity and may also serve as a source of capital accumulation in rural households (Lucas, 1987; Rozelle et al., 1999). In this regard, Debski (2018) investigates the impact of remittances on the expenditure on crop inputs in Ghana and found that remittances influence crop expenditure, and even stronger in lower income groups. By using the Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) for the period 2005-2014, Kinuthia (2020) examines the impact of migration on labour supply and the impact of remittances on farm inputs in maize production in Uganda. According to the study, both local remittances and remittances from abroad have a positive effect on maize production mainly through absorbing the cost of hired labour and pesticides. Similarly, Kapri and Ghimire (2020) analyze the relationship between migration, remittances, and agricultural productivity in Nepal and found remittance as a driver of agricultural productivity. In examining the role of agriculture and foreign remittances in mitigating rural poverty in Pakistan between 1980–2017, Liu et al. (2020) found that agriculture helps to mitigate rural poverty in the long run, but that foreign remittances are more effective in reducing rural poverty in the short-run. The study further confirms the existence of correlations between agriculture, foreign remittances and rural poverty. Using data from a large household survey Adams (2005) found that international remittances significantly relieved poverty among the ‘‘poorest of poor households.’’ Ratha (2003) suggests that remittances that raise the consumption levels of rural households might have substantial multiplier effects, because they are more likely to be spent on domestically produced goods. Some studies have found evidence for ‘‘forward’’ linkages between remittances, and human capital formation in Latin America (Edwards and Ureta, 2003). Other localized studies have concluded that remittances tend to improve the welfare of poorer rural households (Adams, 1991). Studies covering a larger sample of countries have found evidence that remittances tend to lower the poverty (Adams and Page, 2005). A study by Ebadi et al. (2018) on the impact of remittances on food security in the Global South found a significant association between receiving remittances and food security. According to the study, severe food insecurity is significantly related to not receiving remittances. In the same vein, Mora-Rivera and van Gameren (2021) demonstrated that remittances reduce food insecurity in Mexico. Sulemana et al. (2022) investigated the same issue and found that remittances are positively and significantly correlated with household food security.

Contrary to the positive contribution of international migration on the origin economy, Lipton (1980), in his study of 40 villages in India focusing more on internal than international migration, found that migration increases intra-rural inequalities. Similarly, it has been found that migration patterns in East European and former Soviet Union countries are such that richer households receive greater remittances than do poorer households (World Bank, 2007). The evidence on the direct effect of remittances on poverty, and inequality seems to vary according to the sample (Adams, 1991). Earlier studies posited that migration was likely to increase rural inequality, because only relatively better-off households were able to finance a member's search for better employment in urban areas, or abroad (Lipton, 1980). A recent study by Ofori et al. (2022) on 42 African countries demonstrates that remittances heighten income inequality.

In addition to positive and negative effects of remittance, mixed and neutral effects are also common in the literature. Azam and Gubert, (2006) using two surveys performed in the Senegal River valley, in Mali and in Senegal found some mixed results, remittance helped to smooth household consumption through buttressing the family's consumption in case of adverse shock. Equally, they also found this insurance system involved some moral hazard, as those remaining behind tend to exert less effort to take care of themselves, knowing that the migrants will compensate any consumption shortfall, with a high probability. Bucheli et al. (2018) investigate the effects of remittances on child education in Ecuador and finds both positive and negative effects of remittances on the likelihood of schooling. According to the study, the strongest positive effects are for poorer, urban males, while the negative effects are for rural females. For children in wealthier households, the effects of remittances were either negative or non-significant.

A study conducted in Ecuador to examine the effects of international migration on agricultural production and land-use showed that migration neither led to agricultural abandonment nor have remittances been dedicated to agricultural improvements (Jokisch, 2002). Using a tracked sample of migrants in Ethiopia, De Brauw et al. (2013) found that migrants appear to remit for self-insurance rather than to insure the home households, and that migration does have impact on migrant on home agricultural productivity or efficiency.

While the findings of these past studies are instructive by their own, their conclusions are of limited usefulness due to a small sample size, cross sectional nature of the data, and most of them one country case study. Moreover, we could not come across any literature that addresses how the increasing international remittances are affecting agricultural technical efficiency in Africa characterized by an absence of developed credit market and farm household liquidity constraints. That is to say, how does migration affect home country households' production behavior and their ability to achieve technical efficiency in agricultural activities?

It is in this regard that this paper contributes to the literature on the impact of international remittances on agricultural technical efficiency using a sample of almost over 63 per cent of the African countries. We utilize a number of explanatory variables, viz: remittances as a percentage of GDP, mobile penetration, land per capita, credit to private sector as percent of GDP amount of agricultural labor force, regional and time dummies as predictors of agricultural efficiency/inefficiency. Mobile penetration is included in recognition of its effect on reducing the cost of agricultural product price information (reducing transaction cost). It is hypothesized technical efficiency is positively related with land size (in view of fast declining in per capita land size in the face of a growing population). Net official development assistance is hypothesized to positively affect technical efficiency. While the direction of influence of remittances on technical efficiency is difficult to hypothesize a priori, mobile penetration is hypothesized to affect positively efficiency (Lio & Liu, 2006). Regarding the relationship between efficiency and labour force is expected to be negatively related, as more and unskilled labour force is combined with the traditional agricultural technologies in the small household sector.

The rest of the paper is structured as follows. Section 2 describes the research methodology. Section 3 presents empirical results and their discussion. Section 4 concludes.

2. Research methodology

2.1 Sources of Data

The data was obtained from the World Bank database and World Development Indicators. We use data for 34 African countries covering 31-year period (1990-2020). The initial objective was to cover all African countries, clustered into five regions. However, 20 countries were dropped due missing data for the four variables of the production function, viz.: total cereal production (tons); total arable land under cereal production (ha); agricultural labor force and total fertilizer used. To capture the regional difference as well as to simplify our analysis, countries were clustered into five regional categories: Eastern, Southern, Central, Western and Northern Africa. The countries in each group are indicated in Appendix 1. The variables used to explain technical efficiency included remittance as percentage of GDP, mobile cellular subscriptions (per 100 people), credit to private sector as percentage of GDP, agricultural labor forces, regional and year dummies. Missing or none-availability of data has resulted in the exclusion of very important variables such agricultural capital (for agricultural production).

2.2 Model specification

We utilize panel data analysis. One advantage of panel data is that if inefficiency is time-invariant one can estimate inefficiency consistently without distributional assumptions. The assumption that inefficiency is time-invariant might hold true if the time period of the panel is short and the production technology needs more time to change (Battese, and Coelli, 1988; Pitt and Lee, 1981). However, if T (time) is large it becomes plausible to allow inefficiency to vary across time. Hence, in order to capture the time-varying nature of the efficiency, we controlled time in our estimation. In order to account for regional fixed effects, we have also included regional dummies (Eastern Africa=1, Southern Africa=2, Central=3, Western=4 and Northern

). A one-step stochastic frontier approach has also applied to overcome the misspecification of the efficiency levels that might arise from the two-estimation process (Kumbhakar et al., 1990). Moreover, as a robustness check alternative specifications: "true" fixed- (TFE) and random-effects (TRE) models of Greene (2005) also have been estimated with their different distributional assumptions (Table 4 last two columns). However, likelihood test and overall model fitness maximum likelihood random-effects time-varying inefficiency effects model of Battese (1995) has been selected for analysis. Hence, Battese (1995) one-step stochastic frontier production function model for panel data can be specified as follows:

$$Q_{it} = \exp\,(x_{it}\beta + V_{it} - U_{it}) \qquad (1)$$

Where Q_{it} denotes the production at t time (t=1, 2, …31) for the i^{th} country (i=1, 2, …34),

x_{it} is a (1*k) vector of values of input variables of the production function; inputs include, land under cereal production in hectare, agricultural labor force, rainfall, and fertilizer.

β is a (k*1) vector of unknown parameters to be estimated;

V_{it}s are random errors which is assumed to behave iid $N(0, \sigma_v^2)$, and independently distributed of the U_{it}s;

the U_{it}s are non-negative random variables, associated with technical inefficiency of production, again assumed to be independently distributed, such that U_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\delta$, and variance, σ^2;

z_{it} is a (1*m) vector of explanatory variables associated with technical inefficiency of production over time; and

δ is an (m*1) vector of unknown coefficients.

The technical inefficiency effect, U_{it}, in the stochastic frontier model (1) can specified as follows:

$$U_{it} = z_{it}\delta + w_{it} \quad (2)$$

Where z_{it} is the vector of factors affecting technical inefficiency of the i[th] observation (country) and time t; and δ represents parameters to be estimated, while w_{it} is the error term. The vectors included in the Zs includes, agricultural labor force, credit to private sector as percent of GDP, mobile prescription per 100 people, regional and time dummies to control regional fixed effects and path dependence effects.

3. Results and Discussion

3.1 Descriptive Statistics

In order to get an idea on the relative importance of the within and between variation, the decomposed variance is reported in Table 1 below. Comparing the distribution of the variance the between variation is dominant as compared to the within variation. Most of the changes observed in the covariates is due to differences among countries, rather than the potential path dependence (overtime variation). Hence, applying within estimation may lead to considerable efficiency losses. As a result, capturing regional fixed effects will improve the estimation process. Though the between effect is dominant, as we can see from Table 1 the within effect is also very important. Hence, controlling time will help to see the dynamics (the change of efficiency/inefficiency) over time

Table 1 summary statistics of the covariates

Variables		Mean	SD	Observations
Ln Cereal Production Metric ton production	Overall	13.7328	2.4186	N = 1054
	Between		2.4010	n = 34
	Within		0.4988	T = 31
Ln Land under cereal production	Overall	13.5663	2.2947	N = 1054
	Between		2.3047	n = 34
	Within		0.3251	T = 31
Ln Labor Force Agriculture	Overall	15.6908	1.4633	N = 1054
	Between		1.4753	n = 34
	Within		0.1633	T = 31
Ln Labor Force ^2	Overall	248.3398	44.6843	N = 1054
	Between		45.0138	n = 34
	Within		5.3078	T = 31
Ln Rainfall	Between	6.1770	1.8058	N = 1054
	Within		1.3017	n = 34
	Within		1.2707	T = 31

Ln fertilizer	Overall	2.1468	1.6128	N = 1054
	Between		1.5022	n = 34
	Within		0.6394	T = 31
Ln fertilizer^2	Overall	7.2073	8.7079	N = 1054
	Between		8.4165	n = 34
	Within		2.6473	T = 31
Mean-Efficiency	Overall	0.7505	0..2428	N = 1054
	Between		0.2367	n = 34
	Within		0.0673	T = 31
Credit Private % GDP	Overall	23.7971	25.9386	N = 1054
	Between		24.6048	n = 34
	Within		9.2012	T = 31
Ln Mobile Per 100 people	Overall	2.3181	1.9213	N = 1054
	Between		0.4553	n = 34
	Within		1.8682	T = 31
Ln Remittance % GDP	Overall	1.0285	0.8914	N = 1054
	Between		0.7973	n = 34
	Within		0.4206	T = 31
Ln Remittance % GDP^2	Overall	1.8517	3.0641	N = 1054
	Between		2.8035	n = 34
	Within		1.3241	T = 31

Source: World Bank, World Development Indicators and own calculation.

Our analysis of technical efficiency is concerned primarily understanding how the variable of interest (remittances as percentage of GDP) and other variables are affecting agriculture's technical inefficiency of each country (but for simplicity clustered by region). The average efficiency for our sample is 75%. As we can see from Table 2 and Figure 1 below, efficiency distribution is divided into two major groups; the poor performers such as central and Southern Africa concentrated around the left tail and thee three good performers clustered around the head, but weighted average around 70%. When we compare regions in terms of inefficiency, except central Africa, which is insignificant, the three regions North Africa, Western Africa and Southern Africa do show better efficiency as compared to the base eastern Africa. The results are consistent with our expectation, as Eastern and Central Africa are the two regions of hot spot of conflict.

Table 2 Mean efficiency by region

Region	Mean
Eastern Africa	0.8043
Southern Africa	0.6020

Central Africa	0.2693
Western Africa	0.8245
Northern Africa	0.8698
Total	0.7505

Source: World Bank, World Development Indicators and authors' computation.

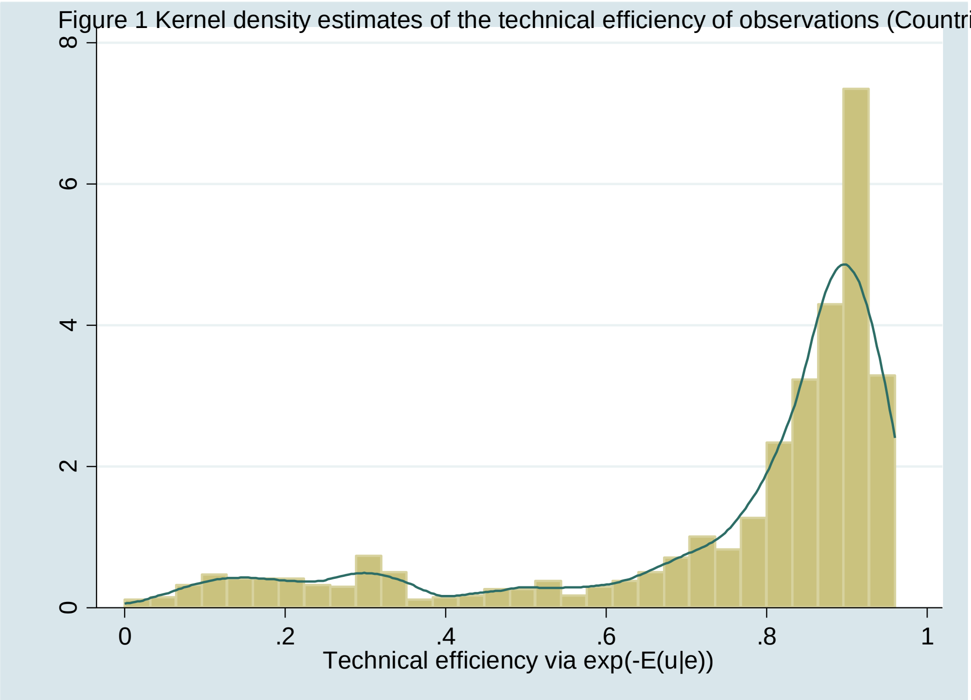

Figure 1 Kernel density estimates of the technical efficiency of observations (Countries)

In terms of efficiency, dynamics (trends across years) though not that much significant, efficiency rate has slightly improved over time (except 2015-2019), from its lowest level 72% in 1990-1994 to 80% in 2020 (Table 3). The descriptive result is also consistent with the results reported in Table 4.

Table 3 Mean efficiency overtime

Year	Mean	SE
1990-1994	0.7248	0.2366
1995-1999	0.7389	0.2395
2000-2004	0.7505	.02289
2005-2009	0.7618	0.02386
2010-2014	0.7691	0.2541
2015-2019	0.7461	0.2601
2020	0.8081	0.2297

Source: World Bank, World Development Indicators and own calculation.

3.2 Model results

The estimated results of the production frontier and efficiency/inefficiency scores based on input oriented stochastic production frontier are reported in Table 4. The first section of Table 4 gives the production function coefficient estimates, which measure the proportional change in output when all inputs included in the model, are changed in the same proportion. It is interesting to note that African farmers are operating almost at constant returns to scale, as the summation of the elasticities is just 1.07 which is consistent with our expectation of the low level of agricultural productivity in Africa; a continent unable to feed its population amid of its plenty natural resource potential. All the inputs were found to be significant indicating the selected inputs' importance in the cereal crop production of the continent. However, land and labor are the most important (with the highest elasticities) inputs, indicating the traditional nature of production organization in the continent.

Table 4 Alternative Model Estimates: the Effects of Remittances on Technical Efficiency

		True Fixed Effect Models	
Variable	ML Random-Effects Time-Varying Inefficiency Effects Model (1)	Fixed Effect (2)	Random Effect (3)
Dependent Variable: Ln Cereal Production Metric ton production			
Explanatory Variables			
Ln Land under cereal production	0.6658 (0.0244***)	0.8101(0.0327***)	0.79555 (0.0197***)
Ln Agricultural Labor Force	0.3165 (0.0254***)	0.7588 (0.0650***)	0.4980 (0.0316***)
Ln Rainfall	0.0420 (0.0075***)	-0.0108 (0.0076)	-0.0099 (0.0067)
Ln fertilizer	-0.0504 (0.0235**)	-0.1135 (0.0365***)	-0.1109 (0.0338***)
Ln Fertilizer^2	0.0523 (0.0045***)	0.0407 (0.0086***)	0.0453 (0.0079***)
Dependent Variable: Mean Inefficiency			
Explanatory Variables			
Ln Agricultural Labor Force	7.8834 (2.6454***)	0.1001 (0.0774)	0.1248 (0.0719*)
Ln Agricultural Labor Force^2	-0.3253 (0.0983***)	-0.0028 (0.0025)	-0.0035 (0.0024)
Credit Private % GDP	0.0325 (0.0041***)	-0.0007 (0.0003***)	-0.0007 (0.0003***)
Ln Mobile Per 100 people	0.1882 (0.2270)	0.0154 (0.0090*)	0.0123 (0.0088)
Ln Remittance % GDP	1.3108 (0.2494***)	-0.0669 (0.0149***)	-0.0596 (0.0145***)
Ln Remittance %GDP ^2	-0.2393 (0.0604***)	0.0172 (0.0044***)	0.0169 (0.0043***)
Region (Eastern Africa=Base)	-	-	
Southern Africa	-2.6945 (0.8348***)	-0.0023 (0.0228)	0.0031 (0.0207)
Central Africa	-0.4474 (0.7202)	0.0560 (0.0435)	0.0508 (0.0405)
Western Africa	-4.0303 (0.8635***)	0.0428 (0.0192**)	0.0398 (0.0179**)
Northern Africa	-5.1381 (1.2222***)	0.0341 (0.0265)	0.0369 (0.0248)
Time dummy			
1990	2.0011 (1.1691*)	0.0857 (0.0502*)	0.0188 (0.0488)
1991	1.9426 (1.1721*)	0.1139 (0.0501**)	0.0495 (0.0487)
1992	2.5730 (1.1504**)	0.0335 (0.0499)	-0.0268 (0.0486)

1993	1.8854 (1.1685*)	0.1046 (0.0498**)	0.0418 (0.0485)
1994	2.1705 (1.1461**)	0.0635 (0.0496)	0.0043 (0.0482)
1995	2.1625 (1.1270**)	0.0685 (0.0493)	0.0095 (0.0479)
1996	1.8496 (1.1300*)	0.1288 (0.0490***)	0.0714 (0.0477)
1997	2.1641 (1.0927**)	0.0502 (0.0486)	-0.0042 (0.0473)
1998	2.0673 (1.0666**)	0.0752 (0.0478)	0.0222 (0.0465)
1999	1.6828 (1.0002*)	0.0821 (0.0465*)	0.0322 (0.0453)
2000	1.7056 (0.8666**)	0.0578 (0.0439)	0.0116 (0.0428)
2001	1.4643 (0.8381*)	0.1026 (0.0420***)	0.0592 (0.0409)
2002	1.9334 (0.7771***)	0.0392 (0.0402)	-0.0002 (0.0391)
2003	1.2709 (0.7627*)	0.0899 (0.0382***)	0.0528 (0.0373)
2004	1.3649 (0.7177**)	0.0704 (0.0363**)	0.0355 (0.0354)
2005	1.3038 (0.6886**)	0.0668 (0.0344**)	0.0365 (0.0336)
2006	1.0444 (0 .6760)	0.0835 (0.0328***)	0.0558 (0.0320*)
2007	1.1678 (0.6433*)	0.0451 (0.0313)	0.0204 (0.0306)
2008	0.9559 (0.6333)	0.0605 (0.0303**)	0.0395 (0.0297)
2009	0.8665 (0.6160)	0.0923 (0.0298***)	0.0714 (0.0291***)
2010	0.5448 (0.6238)	0.1068 (0.0294***)	0.0864 (0.0287***)
2011	0.5301 (0.6177)	0.0810 (0.0291***)	0.0648 (0.0285**)
2012	0.5356 (0.6108)	0.0799 (0.0290***)	0.0631 (0.0284**)
2013	0.6701 (0.6021)	0.0551 (0.0289**)	0.0413 (0.0283)
2014	0.6216 (0.5985)	0.0499 (0.0288*)	0.0376 (0.0283)
2015	0.3124 (0.6268)	0.0554 (0.0289**)	0.0452 (0.0282*)
2016	0.8192 (0.6017)	0.0096 (0.0289)	0.0008 (0.0282)
2017	1.7387 (0.5768***)	0.0159 (0.0289)	0.0064 (0.0282)
2018	0.9639 (0.5957*)	0.0484 (0.0289*)	0.0399 (0.0282)
2019	0.8738 (0.5931)	0.0509 (0.0289*)	0.0445 (0.0282)
2020	Base	Base	Base
_cons	33.5342 (13.9591**)	0.4203 (0.1208***)	-4.5119 (0.3210***)
Usigma	1.0752 (0.4850**)	0.0314 (0.0061***)	-1.4721 (0.0674***)
Vsigma	-2.4341 (0.0970***)	0.1188 (0.0026***)	-3.8040 (0.1295***)
γ	0.97	0.92	0.76
Statistics (N r2_a)	1054	1054	1054

Source: World Development Indicator, The World Bank & Authors estimation

*: P-0.10: **: P= 0.05: ***: P= 0.01 level of significance.

Our objective was to understand which variables are the most important in affecting farmers' production inefficiency. Accordingly, we estimated the technical inefficiency model using the different model specifications (one-step). Results are consistent with our expectations (except remittance as percentage of GDP, yet we do not put a priori expectation). The results show that remittances as percentage of GDP was found to be positively affects at the first stage and negatively related at the quadratic agricultural inefficiency. Which indicates the at the initial stage the small amount households receives adversely competes efficiency enhancing investments, but as the level of remittance reaches at certain stage it enhances efficiency, Similar relates was also reported by Wouterse (2010) . However, it contradicts Sauer et al (2015), which found migration and (remittance) an efficiency decreasing effect in Kosovo.

The second variable is mobile (proxy for infrastructure and information). Mobile technology offers an invaluable support to agriculture, by providing information pertaining prices, technology availability, best practices and weather conditions directly to farmers. Especially for those farmers who do not have physical or financial access to information through conventional extension services. Mobile phones and applications can act as a conduit for locally relevant information. A study by Forestier et al. (2002) also indicated that rural telephony or internet helps farmers to receive better prices for their crops and leads to significantly increased earnings. Hence, mobile, which is assumed, to have negative effects on inefficiency, remained insignificant in our case.

Access to credit, is expected to enhance efficiency by helping farmers accessing the necessary agricultural inputs on time. However, our result, which is highly statistically significant (1% level), was found to be positively related to inefficiency, which contradicts our expectation. This is possibly, higher private credit ratio as percentage of GDP, may not guarantee access to the agricultural sector nor the smallholder farmers, which the dominant in the African continent. The time variable, taking year 2020 as a base all the coefficients were found to be positive (inefficient as compared to the base), indicating an upward moment in efficiency with time. Similarly, except Central Africa, all the variables were found to be highly significant (1 percent) indicating the impact of regional fixed effect on technical efficiency.

The final variable is how the increase in agricultural labor force affects technical inefficiency/efficiency. As indicated, in Table 4, agricultural labor force in its first order form found to be positively affect inefficiency (at 1% level of significance), which is the short-run period where producers are producing with fixed technology; which we can call it the Malthusian stage. However, in the long run the increase in population pre and negatively related in the second order. This indicates that each additional percentage increase in labor force in the agricultural sector tends, until a certain stage tends to affect negative the efficiency level, but after it reaches at higher level of labor force per unit area, labor started to positively influence efficiency. This is against most of the economic literature in the area (citation), but consistent with the Boserupian theory (Boserup, 1965). According to Boserup, the most important factor determining technical change in peasant agriculture is the increasing population /agricultural labor force pressure on the land. Accordingly, to satisfy the food requirement (food output per head) as population grows she argues, producers will be forced to change their techniques of production (Boserup, 1965; John & Levi, 1976). Hence, our first and second order results for the agricultural labor force variable results concords with Boserupian theory.

5. Summary and conclusions

In this paper we used stochastic frontier analysis (SFA) to estimate the technical efficiency of cereal production for 34 African countries and 31 years data, and tried to identify the determinants of efficiency/inefficiency using one step estimation approaches. Future research should be done to replicate, using alternative models, such as Data Envelopment Analysis (DEA) to check the robustness of the results. According to the technical efficiency estimates, output levels could have been maintained while reducing overall input use by an average of 25% for the average country in the sample and about 78% for the most technically inefficient countries. The second question that was addressed is which variables explain efficiency differences among countries and across time. Based on the stochastic frontier estimates, the differences in efficiency were explained by variables such as agricultural labour force management, private credit as a percentage of GDP in the given country (region), level of remittance as percentage of GDP, regional fixed effect and time dummies. Fortunately, most of all these variables are behavioural variables in nature, where government intervention can improve the way they could positively influence technical efficiency outcome variable. Hence, African governments should further improve credit policy which favour the smallholder farmers, which the dominant producers in Africa, and utilization (educating remittance recipients) of remittances, to address the liquidity constraints of smallholder. farmers Hence, governments should push in this (positive) direction to support and help agriculture to play its role in reducing poverty.

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