Agricultural Aid and Agricultural Production in Africa

KWABENA GYIMAH-BREMPONG AND MELISSA GENTRY

ABSTRACT | This paper uses panel data and a dynamic common correlated effect estimator to investigate the effects of non-food agricultural aid on agricultural output in African countries during the 1970 to 2018 period. Using five measures of agricultural outputs in per capita terms and controlling for a number of covariates, we find that non-food agricultural aid, at the aggregate level, has positive and statistically significant short- and long-term effects on agricultural output in African countries. Using disaggregated aid data, we also find that several components of non-food agricultural aid have significant positive effects on agricultural output in Africa, while some components of non-food agricultural aid have no significant effect on agricultural output, suggesting that the composition of the aid matters for aid effectiveness. The results are robust to several specifications and different estimation methodologies including estimators that account for cross-sectional dependence. The results of this paper have implications on aid policy and research.

KEYWORDS | agricultural aid, agricultural production, panel data, cross-sectional dependence, Africa

JEL CODES | F35, I15, O, 019, O55

INTRODUCTION

This paper uses panel data from a sample of African countries and a dynamic common correlated effects (DCCE) estimator to investigate two inter related issues on agricultural aid: (i) What are the short- and long-run effects of

Kwabena Gyimah-Brempong, *Department of Economics, University of South Florida, Tampa, FL 33620, Tel: (703) 798-2438 email: kgyimah@usf.edu and IZA, Bonn;* Melissa Gentry, *University of South Florida, 4202 East Fowler Avenue, Tampa, FL 33620*

doi: 10.5325/jafrideve.21.2.0139
Journal of African Development, Vol. 21, No. 2, 2020

non-food agricultural aid on agricultural output in African countries? and (ii) Which components of agricultural aid are effective in increasing agricultural production? We do so by estimating an agricultural production function with agricultural aid as an added regressor. We start with no prior assumptions about how non-agricultural aid affects agricultural output in African countries. Agricultural aid is provided for specific aspects of agriculture (e.g., agricultural research, improved animal husbandry, food aid etc.), yet investigation of the effects of agricultural aid on agricultural production has been based on aggregate aid to the neglect of aid composition. In addition, previous research on the effectiveness of agricultural aid do not account for possible cross-sectional dependence. Our paper contributes to this literature and the results could help improve aid targeting by both donor and recipient countries.

We investigate the effects of total non-food agricultural aid (*agraid*) and its components on per capita agricultural value added, per capita crop production, per capita food production, per capita livestock production, and cereal yield in African countries during the sample period.[1] We focus on non-food agricultural aid because we are interested in analyzing increased agricultural output in African countries as a way to ensure long-term food security as opposed to short-term food availability that food aid provides. In spite of the role that non-food agricultural aid could play in ensuring long-term food security in Africa, not much attention has been paid to the effect of non-food agricultural aid on agricultural production. While long-term increases in food production in Africa will require increased agricultural investment from domestic sources, non-food agricultural aid could complement such domestic investments.

Previous research on the effectiveness of agricultural aid has focused on the short-run effects of aggregate agricultural aid. It is possible that agricultural aid may have no significant effect in the short-run but may have significant long-run effects; the reverse could also be true. It is therefore important to investigate both short- and long-run effects to get a fuller picture of agricultural aid effectiveness. Agricultural aid has several components; not all of them may be equally effective. It is therefore important to investigate which components of agricultural aid are effective in increasing output. Previous research's focus on aggregate agricultural aid does not allow for the analysis of differential effects of components of agricultural aid. Employing disaggregated agricultural aid allows us to study these differential effects of various components of agricultural aid. It is likely that there are unmeasured common cross-sectional correlated effects of agricultural output and aid across African countries. Not accounting for this cross-country dependence may result in biased estimates. Using the DCCE estimator allows us to account for these common correlated factors. Our study therefore addresses some of the major weaknesses in previous research on the subject.

The United Nations' Sustainable Development Goals (SDGs) make food security the Second Development Goal (SDG2). Apart from food as energy for productive activities, the World Health Organization (WHO) notes that food (in)security is correlated with the risk of serious infectious diseases and malnutrition, which may lead to irreversible loss of cognitive capabilities.[2] This makes increasing agricultural production an important development goal. While increased agricultural output is not sufficient for reduced hunger, it is a necessary pre requisite for food security in low-income agrarian economies, such as those in Africa. Increased agricultural production could also contribute to poverty reduction (SDG1) and SDG8 through faster economic growth; it may also contribute to the achievement of SDG10.

While agricultural output in developing countries has increased in recent years, Africa is the only region of the developing world that imports most of its food (FAO 2018, Rakotoarisoa, Iafrate, and Paschali 2012). Agricultural output in African countries has grown by 1% per annum compared to 2% in other parts of the developing world during the sample period and this growth has come from acreage expansion as opposed to increased yield. The US Department of Agriculture (USDA) calculates that African agricultural imports reached over 48 billion USD in 2014 and most of the predicted 60% increase in food consumption by 2022 will come from imports. According to data compiled from the United Nations' International Trade Centre database, net food imports (food imports minus food exports) into Africa was 5 billion USD in 2001. This figure increased to 20 billion USD in 2010, jumped to 47 billion USD in 2011 before falling to 35 billion USD in 2014 and stabilizing at that figure thereafter.[3] Most of the food imports into Africa are the same types of food produced in Africa (e.g., rice, corn, and other cereal products), suggesting that the major reason for increased net food imports is the inability to increase domestic production to meet increasing demand. It is possible that agricultural aid could help reverse the declining trend in agricultural production by transforming the agricultural sector (Von Braun 2013; Cohen 2015; Norton, Ortiz, and Pardey 1992; Maruta, Banerjee, and Cavoli 2020; Dhahri and Omri 2020; Szozi, Asongu, and Amavilah 2019; among others). Understanding how agricultural aid affects agricultural production therefore has important implications for reducing hunger in African countries.

While total aid to Africa has increased over the past forty years, agricultural aid fell in the 1980s and 1990s by 43% before increasing in recent years, triggered by the 2007/2008 and 2011 food crises (Umbadda and Elgizouli 2018; FAO 2018). Despite the decline in the 1980s and 1990s, African countries still received the largest share of agricultural aid (50%) in the world in 2016. However, agricultural aid was only 4.3% of total aid disbursement to the developing world in 2016, giving it an Agricultural Orientation Index (AOI) of 0.67.[4,5] The evolution of agricultural aid and its components over

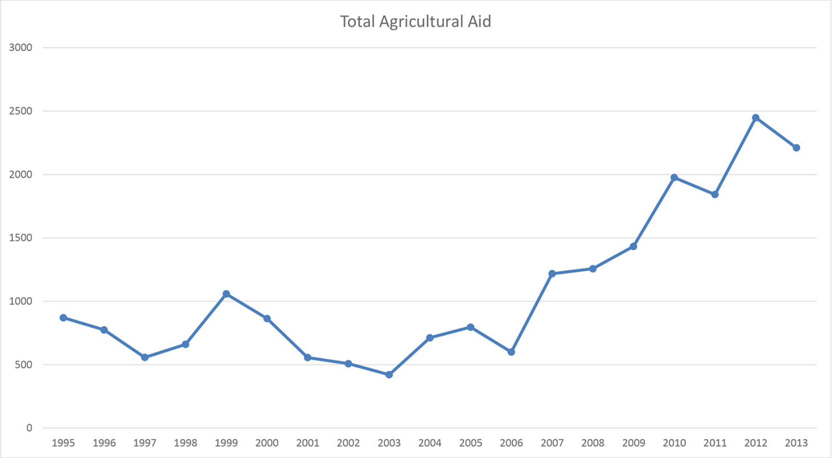

FIGURE 1 | Agricultural Aid to Africa.

the sample period is shown in Figure 1. The figure shows that *agraid* flows to Africa over the period increased marginally overall during the period. The aid data shows that agricultural production received 30% of the total agricultural and rural aid, followed by rural development with 19% and agricultural policy with 16%.[6]

We investigate the effects of non-food agricultural aid on agricultural production. We exclude food aid from the measure of agricultural aid in this paper. We measure agricultural output as total value added per worker in agriculture as well as in crop production, livestock production, food production, and cereal yield. We measure agricultural aid as total non-food aid to the agricultural sector. It is possible that different components of agricultural aid, such as aid for agricultural research or land improvement may affect agricultural output differently compared to the effects of total agricultural aid. It is also possible that a particular component of agricultural aid may affect one component of agricultural output and not others. For example, aid to support agricultural research may increase the production of commercial crops but not food crops or livestock production. Therefore, in addition to investigating the effects of *agraid* on agricultural output, we also investigate the effects of various components of agricultural aid on agricultural output. This finer disaggregation of non-food agricultural aid could inform on agricultural aid policy and research.

This paper makes some contributions to the literature on the effectiveness of agricultural aid in developing countries. This is the only study, we are aware of, that uses the DCCE estimator, which accounts for cross-sectional dependence, to investigate the relationship between agricultural aid and agricultural output in African countries instead of the usual focus on food aid. In addition to the DCCE estimator, we also use the Augmented Mean Group (AMG) estimator and linear dynamic panel maximum likelihood (xtdpdml) estimator to check the robustness of our results. We also investigate the relationship between non-food agricultural aid and five measures of agricultural output instead of a focus on one agricultural output. The paper investigates which components of agricultural aid affect agricultural output, thus providing guidance for better targeting of agricultural aid. Finally, and probably more important, we study both short-and long-run effects of agricultural aid, thus allowing researchers and policy makers to get an idea about the full effects of agricultural aid—something the literature has not generally dealt with.

Our results are briefly summarized as follows: Conditional on other factors, non-food agricultural aid has statistically significant positive effects on all measures of agricultural output in African countries both in the short- and long-runs. However, the absolute magnitude of the effect differs across different components of agricultural output. In addition to the positive effect of aggregate agricultural aid, we find that different components of agricultural aid have mostly positive, significant but different effects on agricultural output. Furthermore while some components of agricultural aid have generally positive effects on some agricultural outputs, a few components of agricultural aid have no significant impact on agricultural output, all things equal. Specifically, aid to support agricultural research, agricultural education and training, livestock development, agricultural development, and agricultural water development have significantly positive effects on agricultural output while aid for the provision of agricultural inputs and land development have no significant impact on agricultural production in African countries.

The rest of the paper is organized as follows: Section 2 provides a brief review of the literature on the effectiveness of agricultural aid, Section 3 discusses the data, Section 4 introduces the equation to be estimated and the estimation method, while Section 5 presents and discusses the statistical results. Section 6 concludes the paper.

BRIEF REVIEW OF THE LITERATURE

The literature on the effectiveness of agricultural aid is very large and cannot be reviewed in one study, hence we focus on summarizing studies that are relevant to this paper. As with the general aid effectiveness literature, the literature on the effects of aid on agricultural output falls into two broad categories—effectiveness of *aggregate aid* on agricultural development and those that focus on the effect of *agricultural aid* on agricultural output. While this paper focuses on the latter category of studies, we nevertheless briefly summarize results from the former category of studies to provide a broader context for our study.

A large number of studies investigate the effects of general aid on poverty reduction through increased agricultural production and find relatively large positive and significant effects on agricultural output and increased rural incomes (Kherellah et al. 1994; Norton, Ortiz, and Pardey 1992; Dhahri and Omri 2020; among others). Madiou et al. (2020) uses time series data to investigate the effects of R&D and aid on agricultural production in Guinea. Using co-integration analysis, the paper finds that aid has significantly positive effects on agricultural value added but no impact on crop production. Mosley and Suleiman (2007) argue that general aid is more effective in reducing poverty and increases inclusive growth if it is targeted toward the agricultural sector rather than to other sectors. The paper shows that aid increases agricultural development generally and food production in particular. Aid increases agricultural output by making it possible to increase expenditures that support agricultural development directly and indirectly (e.g., infrastructure, research, marketing, etc.). Christiaensen, Demery, and Kuhl (2011) finds that aid reduces poverty through increased agricultural output in recipient countries.

A second group of studies focuses on the effect of aggregate agricultural aid on agricultural output in recipient countries. Alabi (2014) uses a two-equation vector auto-regressive model to study the effect of aid to the agricultural sector on agricultural productivity in African countries. Treating agricultural aid as endogenous, the paper finds a positive and statistically significant effect of agricultural aid on agricultural output. Breaking aid into various components and sources, the paper also finds that total agricultural aid, bilateral aid, as well as multilateral aid to the agricultural sector all have significant and positive effect on agricultural output in African countries. Kaya, Kaya, and Gunther (2008) investigates the effects of agricultural aid on the growth rate of the agricultural sector in recipient countries and finds significant positive effects. Using a similar approach, Kaya, Kaya, and Gunther (2013) and Kaya and Kaya (2019) find that agricultural aid significantly decreases poverty and improves aggregate welfare in recipient countries through increased agricultural output and incomes.

Todo and Takahashi (2013) use household level data to investigate the effects of farmer field schools financed with aid from the Japan International Cooperative Agency (JICA) on farmer productivity and incomes in rural Ethiopia. Controlling for a large number of covariates, including farmer and village characteristics as well as types of crops, the paper concludes that participation in the field schools increased farmer productivity and incomes by more than 50% on average. It did this by increasing the agricultural education of the farmers, including ability to access improved seed varieties, agricultural finance, and the mix of crops to produce. Similarly, Fugile and Rada (2013) argue that most of the technological improvements in African agriculture have been the results of work done by Consortium of International Agricultural Research (CGIAR) centers in Africa—centers that are funded with foreign aid. This suggests that research and development funding are mechanisms through which aid to agriculture can increase agricultural output in African countries. Other studies argue that agricultural research has been the source of agricultural productivity growth (Stads and Bietntema 2015; among others). In African countries, funding for agricultural research comes mainly from foreign aid, indicating the importance of agricultural aid in agricultural development in African countries.

A sub set of studies specifically looks at the effect of agricultural aid on agricultural productivity, agricultural production generally, and poverty reduction in that sector and finds a strong positive effect of agricultural aid on agricultural output (Akpokodje and Omojimite 2008; Chimhowu 2013; Mosley and Suleiman 2007; Norton, Ortiz, and Pardey 1992; Umbadda and Elgizouli 2018; and Von Braum 2013). These studies, however, measure agricultural aid as total aid to that sector without excluding food aid. As argued above, food aid does not directly affect production of agricultural output in the long run. In addition, these studies do not disaggregate agricultural aid into its components.

The studies closely related to our study are Ssozi, Asongu, and Amavilah (2019), Mohammead, Rangkakulnuwat, and Paweenawat (2016), Maruta, Banerjee, and Cavoli 2020, Wonyra and Ametoglo (2020), Madiou et al. (2020), and Verter (2017). These studies use either panel data or time series data to investigate the effects of aid (agricultural aid) on agricultural output in low income countries. Ssozi, Asongu, and Amavilah (2019) uses panel data and a variety of estimators to investigate the effects of agricultural aid on agricultural productivity in sub-Saharan Africa. Measuring agricultural aid in a variety of ways, they find that agricultural aid increases agricultural output generally. However, increased aid to food production is negatively and significantly associated with food production, whereas increased aid to commercial (export) crop production leads to increased productivity of export crops. This suggests the existence of substitution of export crops for food crops in production. It also suggests that agricultural aid could possibly lead to increased food insecurity in sub-Saharan Africa. The study also finds that agricultural aid is more productive in countries with good governance. Mohammead, Rangkakulnuwat, and Paweenawat (2016) uses panel data to investigate the sources of agricultural productivity growth in African countries and conclude that the major source of productivity growth is the technical progress in agriculture induced by agricultural aid. Verter (2017) and Madiou et al. (2020) use time series data from Nigeria and Guinea respectively, to investigate the effects of agricultural aid on agricultural output and find that aid to the agricultural sector significantly increases agricultural output, all things equal.

Maruta, Banerjee, and Cavoli (2020) uses panel data to investigate the effects of aid on education, health, and agriculture production in developing countries, and finds that aid to agriculture has a positive and significant effect on agricultural production in African countries. They find that this positive effect increases with institutional quality. Similarly, Dhahri and Omri (2020) uses panel data to investigate the effects of aid and foreign direct investment (FDI) on agricultural production in developing countries. They find that aid to agriculture has significant and positive effects on agricultural production in less developed countries. On the other hand, Wonyra and Ametoglo (2020), using panel data to investigate the effects of remittances on agricultural productivity, concludes that international remittance inflows to Africa have significant negative effects on agricultural labor productivity in African countries. However, the paper does not indicate the overall effects of remittance inflows on agricultural productivity in African countries. From the foregoing review, it is clear that in spite of the large volume of work on the effects of aid generally and agricultural aid in particular on agricultural output, there is little consensus on the subject. There is, therefore, the need for more studies on the subject.

There are studies that conclude that institutions do have significant effects on agricultural productivity in developing countries. Bates and Block (2013) find that electoral competition has positive and statistically significant effect on agricultural productivity in African countries, all things equal. This result is similar to the results of studies that find that aid is effective only in countries with good institutions or policy environment assuming that electoral competition is positively correlated with good institutions/policies. To the extent that agricultural aid can improve institutions, this provides another channel through which agricultural aid could lead to increased agricultural production.

We note that the papers mentioned above do not account for unmeasured common correlation across countries in investigating the effects of agricultural aid on agricultural production. Second, few of these papers focus exclusively on agricultural production in African countries and measure agricultural aid to exclude food aid. Third, all the studies mentioned above measure agricultural output as total agricultural output without disaggregating the outputs to its various components. Similarly, none of the studies disaggregate agricultural aid into its various components. Disaggregating agricultural aid as well as agricultural output into various components may have important aid policy implications. We attempt to tackle these issues in our paper. Finally, these studies only focus on the short-run effects of aid. Because agricultural aid may take long time to take effect, it is important to study both short- and long-run effects.

DATA

Agricultural output can be measured in several different ways depending on the purpose of the investigation. For example, if one is concerned with the effects of agricultural production on income, one may measure agricultural output to include only cash crops and livestock production, while one may measure agricultural output as food crop and livestock if the focus is on food security. In this paper, we measure agricultural output (*q*) in several ways in order to provide a broader context. First, we measure it as total agricultural value added per worker in agriculture (*agvalwk*). Besides *agvalwk*, we also measure various components agricultural output to include crop production per agricultural worker (*crpwk)*, food production per agricultural worker (*fdwk)*, livestock production per agricultural worker (*lskwk)*, as well as cereal yield (*cerealyd)*. These disaggregated measures of agricultural output allow us to investigate how agricultural aid affects total agricultural output as well as the various components of agricultural output. For example, how non-food agricultural aid affects food production relative to export crop production could have implications not only for agricultural production generally, but for domestic food security. The measures of agricultural output we use here are not exhaustive, but suggestive and depend on data availability.

We measure *agvalwk* as the average value added by an agricultural worker in a country in a year in real terms, with 2011 as the base year. We measure *crpwk*, *fdwk*, and *lskwk* as indices of crop output, food crop output, and livestock per worker respectively, with 2004–2006 as the base period. Measuring these agricultural outputs as indices ensure that changes in agricultural output are comparable across countries and through time in a country, given the common

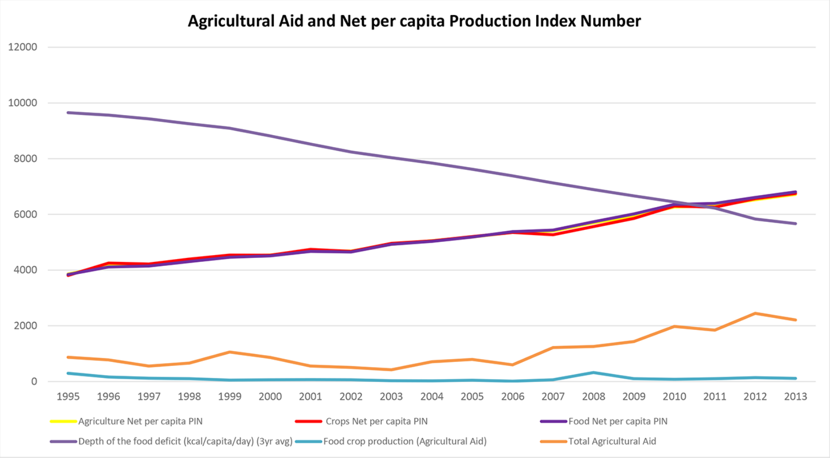

FIGURE 2 | Agricultural Output in Africa.

base of the indices. *cerealyd* is measured as the average yield of cereal (in kgs) per hectare of land planted to cereals in a country.

The evolution of agricultural outputs over the 1992–2016 period are presented in Figure 2. The figure shows that agricultural output increased slowly in Africa during the sample period, but progress was uneven both across countries and through time. Per worker agricultural output declined during the early part of the sample period before rising in the latter part. The components of agricultural output—crop, food, livestock, and cereal yield—changed at different rates during the sample period. In addition, the figure shows that agricultural production in African countries grew at a pace below those of other parts of the world. Regardless of which index one focuses on, Africa and especially sub-Saharan Africa does not fare so well compared to other regions of the world.

The variable of interest in this paper is "aid to the agricultural sector" (*agraid)*. This variable has been measured in different ways by earlier researchers. While some of the earlier research distinguish between aggregate aid and aid to the agricultural sector, these researchers have generally included food aid in their measure of agricultural aid. Because we are concerned with agricultural production, we exclude food aid from our measure of *agraid*. Besides aggregate aid to the agricultural sector, *agraid* has several components that may have differential effects on different aspects of agriculture. Components of *agraid* include aid for agricultural research, agricultural inputs, education and management of the agricultural sector, agricultural land preparation, agricultural water resource management, and extension services.

We measure *agraid* in two ways. First, we measure *agraid* as total real per capita aid to the agricultural sector, net of food aid (*agraid*). Second, we measure agricultural aid in disaggregated components as the budget share of aid to specific sub-sectors. The components of agricultural aid we use in the analyses are aid to support agricultural research (*agres*), agricultural education and training (*agedutr*), livestock development (*aglsk*), aid for agricultural land development (*algr*), aid for the purchase of agricultural inputs, such as improved seed, fertilizer, and agricultural machinery (*aginp*), aid for irrigation and water development (*agwr*), and for the management and development of the agricultural sector (*agdev*).[7] In all cases, we measure *agraid* as agricultural aid *disbursed* to a country in a year rather than aid *commitment* as has been the case in previous research. We believe that disbursed aid is a more relevant measure, since it is the actual amount of aid that is available to the recipient country.

Traditional agricultural inputs used to estimate the agricultural output equation include arable land per agricultural worker (*arable*), percent age of agricultural land that is irrigated (*irrigate*), annual precipitation in a country (*rain*), agricultural machinery represented by the number of tractors per 100 square kilometers of farmed land (*tractors*), and fertilizer use (*fertcon*). *rain* is measured as the average annual precipitation in depth (in millimeters), while *fertcon* is measured as total fertilizer amount of (all kinds) use (in kgs) per hectare of farmed land in a country. We measured *irrigate* as the proportion of farmland that is irrigated in a country. We also include political stability (*polstab*) as an added variable. We measure *polstab* as index that ranges from-2.5 to 2.5 with low numbers indicating political instability, while high numbers indicate political stability. We also include an index of governance in the robustness tests.

The data for estimating the q equation were obtained from a variety of sources. The data for agricultural output, agricultural land, irrigation, rain, and fertilizer consumption were obtained from the United Nations' Food and Agricultural Organization (FAO) *Food Security Indicators, 2018*, (downloaded from http://www.fao.org/economics/ess/ess-fs/ess-fadata/en/#.V). Similarly, the agricultural aid data were obtained from FAO's ADAM project website at www.fao.org/tc/adam/data/index.html and supplemented with data from FAO's economic and social sector food security data archives and Organisation for Economic Co-operation and Development's (OECD) *Aid to the Forestry, Fishing, and Rural Development Sectors*, downloaded from www.oecd.org/agriculture. These data sets were complement with data from the World Bank's *World Development Indicators, 2018* downloaded from https://www.data.worldbank.org/products/wdi.

Data for political instability (*polstab*) were obtained from the World Bank's *Worldwide Governance Indicators, 2018*, which was downloaded from http://databank.worldbank.org/data/reports.aspx?source=Worldwide-Governance-Indicators. The Governance Indicators series start with 1996 rather than 1970 as the other series do. We used a cubic spline to interpolate the *polstab* to 1970. The data represent 45 African countries over the 1970 to 2018 period.[8] To reduce the noise-to-signal ratio in the annual data, we follow earlier researchers and take four-year averages of the data. Excluding a few years without the complete set of observations, we get 13 periods combined with 45 countries that gives a total of 585 observations for the study.

Summary statistics of the data are provided in Table 1. The data shows that total per worker agricultural output as well as the components of agricultural output in African countries that tended to be low, although highly variable, and have grown very slowly. Figure 2 indicates, however, that agricultural production in African countries improved over the sample period although there was a lot of regional variation and also variation across indices during the sample period. The mean value of aid to agriculture in Africa was relatively high during the sample period. The data in Table 1 and Figure 1

TABLE 1 | Summary Statistics of Sample Data+

Variable	*Mean**	*Standard Deviation*	*Minimum*	*Maximum*
		Agricultural Output Indices		
agvalwk (2004 = 100)	100.89	21.12	44.83	178.58
crpwk (2004 = 100)	78.13	40.89	2.61	452.84
lskwk (2004 = 100)	71.20	35.42	10.23	245.50
fdwk (2004 = 100)	74.38	34.05	13.34	208.32
cerealyd (kg per hectare)	1218.82	1025.98	34.3	9453.70
		Agricultural Aid		
agres (%)	36.88	59.33	0.00	100.00
agedutr (%)	40.02	60.77	0.02	100.00
aglsk (%)	8.18	15.61	0.01	97.88
agdev (%)	10.15	23.92	0.00	100.00
algr (%)	23.89	21.12	44.83	100.00
agwr (%)	42.65	38.54	5.26	98.38
aginp (%)	23.21	68.62	3.29	78.29
agraid	20.27	40.99	0.00	395.82
		Other Regressors		
GDP_{ppp} (PPP_{2000})	4433.67	5879	336.69	36059.20
rain (mm per annum)	970.76	643.95	51.0	2391.0
aleirri (%)	11.44	22.97	0.10	100.00
goveffect	-0.548	0.891	-2.32	1.91
irrigate	3.75	6.69	0.0005	23.08
polsab	-0.55	0.924	-3.32	1.19
arable (ha/person)	0.2350	0.1723	0.0013	1.4419
fertcon (tons/ha)	0.3533	0.97	0.0016	6.816
tractor (per 100 km^2)	37.58	83.46	0.004	1170.0
N	585			

* these are unweighted averages.

+ Based on author's calculations.

also show that aid to the agricultural sector varied widely during the sample period, generally falling during periods of relative food availability and increasing sharply after periods of negative world food supply shocks. Overall, however, aid to agriculture in Africa at the end of the period was not significantly different from its volume at the beginning of the sample period.

MODEL AND ESTIMATION METHOD

This section introduces the reduced form of the agricultural production function equation that we estimate, as well as discusses the estimators used to estimate the equation. The first subsection presents the equation, whereas the second subsection discusses the estimators we use in this study.

Model

There are several reasons why *agraid* could increase agricultural production in recipient countries in both the short and long runs. First, *agraid* could lead to increased support for agricultural research that develops new and improved technologies (Alabi 2014; Kherallah et al. 1994; Stads and Bientema 2015; Umbadda and Elgizouli 2018). Second, *agraid* could lead to the adoption of improved agricultural technologies, especially through the provision of extension services, irrigation, and land preparation. Third, *agraid* could lead to efficient management of the agricultural sector generally, provide increased returns on agricultural investment, and hence in centives for farmers to further invest and increase output. Fourth, *agraid* could lead to the acquisition and use of modern inputs such as fertilizer, improved seeds, machinery, and irrigation. Fifth, *agraid* could create markets for local farmers and may also lead to the development of markets and better distribution systems for agricultural products that provide producers with incentives to expand output. Finally agricultural aid could result in improved quality and use of existing inputs such as water and land. Stads and Beintema (2015) and Mohammed, Rangkakulnuwat, and Paweenawat (2016) argue that agricultural research and development (R & D) is critical to long-term sustainable agricultural development. Given that technical change in agriculture, especially those related to land productivity increases, is a public good, optimal investment to bring about this type of change will involve public financing, which in African countries, implies aid sources. Slow growth or volatility in the flow of aid for agricultural research has negative consequences for agricultural development. Thus, one pathway through which agricultural aid affects agricultural output is the R & D channel. Cohen (2015) notes that the emphasis of US agricultural aid is shifting away from food aid to long-term agricultural output as the current Feed the Future Program focuses on increasing agricultural output and yields.

We follow earlier research and present a simple Cobb-Douglas agricultural production function. We follow earlier researchers and assume that agricultural output (Q) depends on agricultural technology, agricultural inputs, and environmental factors. The equation is written in a general form as: $Q = \lambda f(\mathrm{K,L,N}), \lambda > 0, f' > 0,$ where λ is a technology indicator, K, L, N are capital, labor, and land inputs respectively. We assume that λ depends on aid to agriculture as well as environmental factors (Z), that is, $\lambda = \lambda(A, Z)$, where A is aid to the agricultural sector, and Z is a vector of environmental factors. Substituting λ into the Q equation, the agricultural production function can be written in general form as a function of agricultural aid, environmental factors, and traditional agricultural inputs, that is, $Q = f(K, L, N, A, Z)$. Dividing the Q equation by labor inputs, we can write the equation in per unit of labor terms as $q = q(a, k, n, Z)$, where lowercase characters are per capita variables. If agricultural aid has a significant effect on agricultural production, we expect its first derivative of per worker agricultural output with respect to aid per capita to be positive.

This specification is similar to those specified and estimated in previous research (Kaya, Kaya, Gunther 2013; Kaya and Kaya 2019; Norton, Ortiz, and Pardey 1992; Szozi, Asongu, and Amavilah 2019; Akpokodje and Omojimite 2008; Alabi 2014; Kahsay and Hansen 2019; Umbadda and Elgizouli 2018; Dhahri and Omron 2020; Maruta, Banerjee, and Cavoli 2020; among others). The reduced form q equation is written in a very general form that cannot be estimated. We need to provide a specific functional form as well as define the variables that enter the equation to make it estimable. For simplicity, we choose a linear functional form for this equation. The variables we use to represent k, n, and Z are the traditional agricultural inputs that have been used to estimate agricultural production functions by earlier researchers. In addition to traditional agricultural inputs, previous research include political stability or institutional quality variables in the q (Szozi, Asongu, and Amavilah 2019; Bates and Block 2013; Kaysay and Hansen 2019; among others). We therefore include political stability (*polstab*) as an added regressor.

We write the reduced form q equation we estimate in a linear form as:

$$q_{i,t} = \alpha_1 agraid_{i,t} + \alpha_2 irrigate_{i,t} + \alpha_3 tractor_{i,t} + \alpha_4 arable_{i,t} +$$

$$\alpha_5 rain_{i,t} + \alpha_6 fertcon_{i,t} + \alpha_7 polstab_{i,t} + \lambda q_{i,t-1} + \gamma_i + \tau_t + \varepsilon_{it} \quad (1)$$

where *irrigate* is irrigation, *polstab* is political instability, *arable* is per capita arable land, *fertcon* is fertilizer use per hectare of cultivated land, *rain* is average annual precipitation in a country, *tractor* is the number of agricultural tractors per 100 square kilometers of farmed land, q_{t-1} is agricultural output in the previous period, γ is country fixed effect, τ_t is time trend, ε_{it} is a stochastic error term, α_is and λ are coefficients to be estimated, and all other variables are as defined above. We include a lagged dependent variable as a regressor in the q equation on the assumption that the current level of agricultural output is influenced by past levels of agricultural output. This variable may also capture the effects of omitted regressors.

If q is positively related to *agraid*, political stability, irrigation, arable land per agricultural worker, and fertilizer use, we expect the coefficients of these variables to be positive and significant, all things equal. In addition to the q equation, we use the same equation to investigate whether different components of agricultural aid have significant effects on various agricultural outputs in African countries.

Estimation Methods

We estimate the q equation with panel data from a sample of African countries. The equation has potentially endogenous regressors (*agraid)* and agricultural inputs as well as a lagged dependent variable. Researchers have used variants of Arellano and Bond's dynamic panel data (DPD) estimator to obtain consistent estimates for such models. There are two concerns with the DPD estimators in these circumstances. First, the estimator assumes that the relationship between agricultural aid and agricultural output is the same across all countries in the sample. It is, however, unlikely that the effects of agricultural aid on agricultural output in Chad will be the same as the relationship between the two variables in Kenya or Nigeria partly because of the differences in economic structures across countries. Second, the DPD estimator assumes that there is no cross-country dependence among the regressors and outputs across countries. However, it is most likely that agricultural output as well as agricultural aid in African countries are affected by unobserved common factors such as weather, possible correlated aid receipts, and conditions in agricultural export markets. These countries also intensively trade among themselves in agricultural outputs and inputs. Failure to account for these cross-country dependence will likely lead to biased estimates. One, therefore, needs an estimator that accounts for heterogeneous slopes as well as cross-sectional dependence to obtain consistent estimates. The DCCE estimator suggested by Chudik and Pesaran (2015) is one such estimator.

The Dynamic Common Correlated Effects Estimator (DCCE)

The systems DPD estimator that has been used to estimate cross-country growth regressions assume that there is no cross-country correlation among the error terms and that the relationship between *agraid* and agricultural output is the same across countries. However, as indicated above, it is not likely to be the case. Agricultural output in African countries are likely to be influenced by common factors such as business cycles or weather changes across African countries. It is also most likely that agricultural aid itself may be correlated across African countries on account of common sources as well as the possible correlation of agricultural output across these countries. Finally, these countries trade among themselves in both agricultural outputs and inputs, especially agricultural labor. Failure to account for these possibilities in estimation may lead to biased and inconsistent estimates. We therefore estimate the equation with a DCCE estimator (Chudik and Pesaran 2015; Li et al. 2020).

If the error terms in (1) are correlated across countries through some common factors, then $q$will also be correlated across countries through the error terms. In this case one can write equation (1) as:

$$q_{i,t} = \alpha_1 agraid_{i,t} + \alpha_2 irrigate_{i,t} + \alpha_3 tractor_{i,t} + \alpha_4 arable_{i,t} + \alpha_5 rain_{i,t} +$$

$$+ \alpha_6 fertcon_{i,t} + \alpha_7 polstab_{i,t} + \lambda q_{i,t-1} + \gamma_i + \tau_t + \varepsilon_{it}$$

$$\varepsilon_{it} = \sum_{l=1}^{m} \delta_i f_{i,t} + \varepsilon_{it}$$

where all variables are as defined in (1) above, α_i is country-specific coefficient, which may differ across countries, f is a vector of unobserved cross-country common factors, and m is the number of common factors. $\alpha_i = \alpha+v_i$, $E(v_i) = 0$, implying that $E(\alpha_i) = \alpha$. Inserting the error term equation into the q equation produces a q equation that accounts for cross-country common factors. Chudik and Pesaran (2015) and Li et al. (2020) show that estimating this equation with cross-country averages of the dependent as well as the regressors as additional regressors produces consistent and efficient estimates. The DCCE estimator is robust to the presence of a limited number of "strong" factors as well as to the presence of infinite number of "weak" factors.

In estimating the q equation, we allow for two period lags to calculate the cross-country averages. This two-period lag was chosen as the cubic root of the time dimension of the series ($T^{1/3}$), as is the general practice in the literature. α_i is estimated for each cross-sectional unit and the panel coefficient is calculated as the average of the estimates for cross sections; ($\hat{\alpha} = 1/N \sum \hat{\alpha}_i$). The long-run effects are calculated as: $LRE = \hat{\alpha}/(1-\lambda)$. This DCCE estimator allows for heterogeneous coefficients as well as calculate short- and long-run effects. We use the xtdcce2 routine in STATA for the DCCE estimation (Ditzen 2018).

The xtdpdml Estimator

In addition to the DCCE estimator, we estimate the equation with the linear dynamic panel data maximum likelihood estimator (xtdpdml) suggested by Williams, Allison, and Moral-Benito (2019). This is a maximum likelihood-based dynamic panel data estimator that is consistent, efficient, and does not require that all variables be time-varying.[9] The xtdpdml estimator has advantages and disadvantages. Unlike other panel data estimators, it ensures that coefficients for all strictly exogenous time-invariant variables can be estimated. Second, the xtdpdml estimator is able to handle missing variables instead of deleting observations as other non-maximum likelihood panel data estimators do. It is well known that when the series are highly persistent as agricultural output and inputs in African countries are likely to be, panel data estimators based on first differences tend to impart a bias to the coefficient estimates, while the ML-based xtdpdml is not so affected. Finally, the xtdpdml has better small sample performance than the General Method of Moments (GMM) or least squares-based dynamic panel data estimators.

On the negative side, the xtdpdml does not always converge during estimation, hence it may not produce coefficient estimates. Second, the xtdpdml estimator makes some restrictive assumptions. In particular, it assumes a multi-variate normal distribution of endogenous and exogenous variables and that the unobservable time invariant country fixed effects are uncorrelated with the timeinvariant strictly exogenous variables. Third, the xtdpdml estimator cannot account for common correlated effects in estimation. In spite of these potential weaknesses, we use the xtdpdml estimator not only for robustness check on our DCCE estimates, but also allows us to compare estimates that account for cross-country correlated effects and those that do not.

RESULTS

This section presents and discusses the regression results. The first subsection discusses the results based on measuring agricultural aid as total agricultural aid (*agraid*), while the second subsection presents and discusses the effects of the components of agricultural aid on agricultural output. The first sub section also includes a series of robustness tests as well as estimates based on the xtdpdml estimator.

Before estimating the equation, we use the Im-Pesaran-Smith (IPS) panel unit-root test to investigate the time-series characteristics of key variables of the data to see if the series are stationary. We use the IPS test partly because it relaxes the assumption of common auto-regressive parameter for all panels as other panel unit root tests assume. Second, unlike other panel unit root tests, it does not require a balanced panel. Based on information criteria (Akaike, BIC), we allow for two lags in conducting these tests. The results are presented in columns 2 and 3 of Panel A in Table 2. The test statistics (**W-t-bar**) show that with the exception of *fdwk*, we cannot reject the null that the series have unit root in levels but we can reject the null for the first difference of the variables indicating that they are all difference stationary.

The IPS panel unit root test does not account for cross-sectional dependence in the data, hence will not detect possible cross-country correlation among agricultural inputs and outputs in African countries. We therefore augment the IPS unit root test with Pesaran's second generation unit root test (Pesaran's CIPS, Persaran 2007), which accounts for cross-sectional dependence, to test for panel unit roots that accounts for possible cross-country correlation among the variables. The results of the CIPS unit root tests are presented in columns 4 and 5 of Panel A in Table 2. Similar to the IPS results, the **Z-t-bar** statistics suggest that the panel variables are first difference stationary but not generally at the levels. This means that we can estimate the model in first difference of the variables rather than in levels.

As indicated above, there is a high likelihood that there is cross-country dependence of agricultural output and inputs across African countries that may result in correlation between the error term and explanatory variables. This is confirmed by the results of the CD tests, which tests for weak cross-country dependence, in Panel B of Table 2. The test results show that there is evidence of weak cross-country correlation in *agraid* and all agricultural output and input. We therefore use the DCCE estimator (Chudik and Pesaran 2015; Chudik et al. 2017; Li et al. 2020; Ditzen 2018, 2019) to estimate the model. We estimate the equation using the xtdcce2 routine in STATA written by Ditzen (Ditzen 2019).

Total Agricultural Aid

We present our initial results based on measuring agricultural aid as *agraid* in the first part of the sub section. This is followed by a series of robustness checks based on measuring agricultural aid as *agraid*.

Initial Results

The DCCE estimates of the various components of the agricultural output equations using *agraid* as our measure of agricultural aid are presented in Table 3. Column 2 presents the estimates for the per capita total agricultural production equation (*agvalwk)*, column 3 presents the estimates for the per capita crop production equation (*crpwk)*, column 4 present the estimates for the per capita livestock production equation (*lskwk)*, column 5 presents the estimates for the per capita food production equation *fdwk*, while column 6 presents the estimates for cereal yield (*cerealyd)*. For all columns, we present the short-run estimates of all variables in the top part of the table as well as the long-run effects of *agraid* and the estimate for the co-integration variable (q_{t-1}). Regression statistics show a good fit of the *q* equation to the data. Based on the F statistic, we reject the null hypothesis that all slope coefficients are jointly equal to zero at

TABLE 2 | Panel Unit Root and Cross Sectional Dependence Tests[*]

Panel A:	*Panel Unit IPS*	*Root Test*	*Tests CIPS*	*Test*
Variable	*W-t-bar*	*p-value*	*W-t-bar*	*p-value*
agvalwk				
Level	0.2692	0.6005	0.961	0.30
First difference	-16.528	0.00	-12.10	0.00
crpwk				
Level	0.2	0.6142	1.028	0.34
First difference	3.109	0.01	4.211	0.01
agraid				
Level	-2.7793	0.003	-1.210	0.03
First difference	-7.5898	0.00	8.290	0.00
fdwk				
Level	0.26	0.86	0.38	0.72
First difference	6.82	0.00	5.281	0.00
lskwk				
Level	1.1152	0.8752	1.862	0.05
First Difference	-4.2981	0.00	-4.862	0.001
cerealyd				
Level	0.6802	0.8318	0.618	0.728
First Difference	11.1891	0.00	10.862	0.00
crpwk				
Level	1.05	0.8548	0.861	0.892
First Difference	4.3781	0.00	4.218	0.001
arable				
Level	-1.2321	0.394	-1.427	0.381
First Difference	8.6928	0.00	6.921	0.00
Panel B:	**Cross Sectional**		**Dependence Test**	
Variable	**CD Statistic**		***p-value***	
agraid	40.291		0.00	
agvalwk	38.703		0.00	
crpwk	42.484		0.00	
lskwk	42.493		0.00	
fdwk	42.607		0.00	
cerealyd	41.358		0.00	
tractor	31.603		0.00	
irrigate	19.413		0.00	

[*]From author's estimates.

α = .01 for all output equations. The CD statistics show that all agricultural output equations have unmeasured common factors. Not accounting for these unmeasured common factors may lead to biased and inconsistent results.

With the exception of *lskwk* and *fdwk*, the short-run coefficient estimate of *agraid* is positive and significantly different from zero at α = .05 or better in all agricultural output equations. An increase in total non-food agricultural aid to

African countries leads to an increase in all agricultural output, all things equal. The exceptions are aid to support livestock or food production where we find no significant effects of *agraid* at $\alpha = .05$. The estimated short-run effects of total nonagricultural aid on per capita agricultural output are 0.09, 0.012, and 0.03 for *agvalwk*, *crpwk*, and *cerealyd*, respectively. The estimates suggest that, all things equal, non-food aid to the agricultural sector generally have significantly positive effects on per capita agricultural output in the short run, although the absolute magnitudes of the effects are small. Because we measure agricultural output in per capita terms, however, the positive and significant effect we find here suggests that agricultural aid increases agricultural output relative to population growth.

The estimates of the effects of *agraid* on agricultural output we find here are similar to the results of previous research that find that agricultural aid increase agricultural output (Akpokodje and Omojimite 2008; Alabi 2014; Kaya, Kaya, and Gunther 2008, 2013; Kaya and Kaya 2019; Madiou et al. 2020; Szozi, Asongu, and Amavilah 2019; Kherallah et al. 1994; Mosley and Suleiman 2007; Norton, Ortiz, and Pardey 2007; Dhahri and Omri 2020; Todo and Takahashi 2013; Umbadda and Elgizouli 2018; McArthur and Sachs 2018; Von Braun 2013; among others). It is also consistent with the results of research that finds that aid to the agricultural sector increases agricultural incomes in recipient countries, all things equal. We note that the absolute magnitude of these estimates are generally lower than those of earlier researchers who find significant positive effect of agricultural aid in African countries. The insignificant short-run effect of *agraid* on *lskwk* and *fdwk* is consistent with the results obtained by Ssozi, Asongu, and Amavilah (2019).

The long-run estimates of the effects of *agraid* are presented at the bottom of Table 3. The estimates of the co-integration variable (q_{t-1}) is positive, relatively large, and significantly different from zero at $\alpha = .01$ for all output equations. The estimates are also significantly less than unity, indicating a stable long-term relationship between agricultural output and the regressors. The estimated long run effects of *agraid*, calculated from equation (2) are 0.371, 0.396, 0.3109, 0.35, and 0.308 for *agvalwk*, *crpwk*, *lskwk*, *fdwk*, and *cerealyd*, respectively. These estimates indicate that there is a significant positive, long-term relationship between agricultural aid and agricultural output in African countries, all things equal. It is interesting to note that the long-run estimates are much larger in absolute magnitude than the short-run effects, all things equal. Moreover, while the short-run effects of *agraid* on *lskwk* and *fdwk* equations are not statistically significant, the long-run estimates are significant at $\alpha = .05$, suggesting that while *agraid* may have no shortrun effects on these measures of agricultural outputs, it has long-term significant positive effect. This result is consistent with results of research that finds that aid to the agricultural sector has significantly positive effects on agricultural output, all things equal.

TABLE 3 | Agricultural Production Equation: Total Agricultural Aid

Variable	*agvalwk*	*crpwk*	*lskwk*	*fdwk*	*cerealyd*
	(2)	*(3)*	*(4)*	*(5)*	*(6)*
			Short Run Estimates		
agraid	0.0928**	0.0124**	0.0642	0.1234	0.0342***
	(2.29)	(1.99)	(0.88)	(1.43)	(3.01)
irrigate	0.1814***	0.1398***	0.0133***	0.1623***	0.0189***
	(5.08)	(6.21)	(3.01)	(3.75)	(4.41)
tractor	0.0186**	0.0162**	0.0141	0.0624	0.0141**
	(2.16)	(2.92)	(0.86)	(1.06)	(2.36)
polstab	0.1851***	0.1436***	0.0912**	0.2177***	0.0216***
	(3.34)	(3.41)	(2.14)	(3.32)	(3.21)
fertcon	0.0022***	-0.3991	-0.9912	-0.3889	0.228**
	(4.11)	(1.28)	(1.12)	(1.22)	(2.16)
arable	0.3421***	0.9282**	0.2664**	0.4912***	0.3789
	(2.89)	(2.35)	(2.45)	(3.05)	(1.00)
rain	0.1181***	0.1365***	0.1486***	0.1862***	0.1026***
	(3.29)	(3.21)	(3.28)	(4.21)	(3.02)
			Long Run Estimates		
q_{t-1}	0.4288***	0.5246***	0.5131***	0.5572***	0.5277***
	(10.21)	(13.18)	(4.99)	(13.40)	(16.64)
agraid	0.3714	0.3966**	o.3409**	0.3209**	0.6081***
	(3.03)	(2.82)	(2.19)	(2.77)	(3.02)
CD	3.70	-3.67	3.82	2.97	2.78
p – value	0.00	0.00	0.00	0.00	0.01
Panel Group	45	45	45	45	45
F(523, 339)	12.69	5.49	8.92	9.28	9.89
Adjusted R^2	0.66	0.56	0.58	0.52	0.59
N	585				

Dependent Variable: Agricultural Output

+ absolute value of "t" statistics in parentheses.
* 2-tail significance at α = 0.10
** 2-tail significance at α = 0.05
*** 2 tail significance at α = 0.01

The coefficient estimates of the control variables are of the expected signs and are, in most parts, significantly different from zero at conventional levels. The coefficient estimates of all traditional agricultural inputs—*arable*, *irrigate*, *irrigate*, *fertcon*, *rain*, *tractor*—are positive, and significantly different from zero at α = .05 or better in all agricultural output equations. The only exceptions are *fertcon* in the *crpwk*, *lskwk*, *fdwk* equations and for *tractor* in the *lskwk* and *fdwk* equations. It is most likely that these exceptions may be a reflection of the low levels of fertilizer and machine use in the production of these products.

The estimates suggest that the *q* we estimate is a good representation of agricultural production functions in African countries. The coefficient of *polstab* is positive and significantly different from zero at $\alpha = .05$ or better in all agricultural output equations, an estimate that is consistent with theoretical expectations and consistent with the results of previous research that conclude that political instability has significantly negative effects on development outcomes. This indicates that the presence of political stability is associated with increased agricultural production in African countries, all things equal. The positive coefficient of *arable* is consistent with the observation that increased agricultural output in African countries has been due to acreage expansion rather than yield increases.

Robustness Tests

This subsection presents some robustness checks on the estimates presented in Table 3. A hypothesis in the aid effectiveness literature is that aid is only effective in countries with good governance or policies (conditional aid effectiveness) or governance enhances the effectiveness of aid (Szozi, Asongu, and Amavilah 2019; Dhahri and Omri 2020). Our specification of the relationship between *agraid* and agricultural output in African countries does not include governance. It is possible that our results could have been influenced by the exclusion of governance. Therefore, the first robustness test we conduct is to estimate the agricultural output equation that adds the interaction between governance and *agraid* as an added regressor to see if this specification affects our results. The estimate presented in Table 3 is based on entering the *agraid* variable in a linear form. It is possible that agricultural aid is subject to diminishing returns and that excluding the quadratic term could affect our results in a negative way. We therefore estimate a *q* equation that enters agricultural aid in a quadratic form. This is the second specification test we conduct.

The data shows that Egypt's use of fertilizer—about 2.5 times the average—is an outlier. This may affect the coefficient estimates, especially the coefficient of *fertcon*. The third robustness test we conduct is to estimate the agricultural output equation that exclude Egypt from the sample. Although the DCCE estimator produces consistent and efficient short-and long-run estimates of the *q* equation, it treats the estimates of the common factors as nuisance parameters without economic interpretation. On the other hand, the AMG estimator, introduced by Eberhardt and Teal (2010), jointly estimate the common factors and interpret the estimates as measures of total factor productivity (TFP), an approach that is consistent with economic theory and empirical tests of cross-country production functions.[10] We therefore use the AMG estimator, which, like the DCCE, also accounts for cross-country dependence to estimate the *q* equation as another robustness check on the DCCE estimates. Most panel data studies of the relationship between *agraid* and agricultural output employ some version of the dynamic panel data estimator. It is possible that the DPD estimator could produce different results. Therefore, the last robustness test we conduct is to use the two-step system dynamic panel data estimator (SYS-DPD) to estimate the *q* equation.

The results of these robustness test equations are presented in Table 4. Panel A presents the conditional aid effectiveness specification, Panel B presents the quadratic specification, Panel C presents the estimates of the equation that excludes Egypt from the sample, Panel D presents the AMG estimates, while Panel E presents the sys-dpd estimates.[11] Table 4 presents only the long-run effects of *agraid*. As in Table 3, column 2 presents the estimates for *agvalwk*, column 3 presents the estimates for *crpwk*, column 4 presents the estimates for *lskwk*, column 5 presents the estimates for *fdwk* and column 6 present the estimates of *cerealyd*. Regression statistics (not reported here for space consideration) indicate good fit for all equations to the data set. In particular, we reject the null hypothesis that all slope coefficients are jointly equal to zero at $\alpha = .01$ for all equations on account of F statistics. There is no evidence of second-order correlated effects in the sys-dpd estimates.

In Panel A, the estimate of *agraid* is positive and significantly different from zero at $\alpha = .01$ in all agricultural output equations. These estimates across all equations are *qualitatively* similar to the estimates of *agraid* in Table 3. While the absolute magnitude of the coefficient of *agraid* in Panel A of Table 4 is different from their counterparts in Table 3, they are *qualitatively* the same. The estimate of agricultural aid/governance interaction term is positive and significantly different from zero at $\alpha = .05$ or better in all equations, suggesting that better governance improves the effectiveness of agricultural aid in African countries. We note that the inclusion of the governance/aid interaction term does not *qualitatively* change the coefficient on the agricultural aid variable.

In addition to the similarities of the coefficients of *agraid* in Table 3 and those in Panel A of Table 4, tests of equality between the estimates in Tables 3 and 4 produced χ^2 statistics of 1.62, 1.73, 1.49, 1.42, and 1.62 for the *agvalwk, crpwk, lskwk*, *fdwk*, and *cerealyd* equations, respectively, suggesting that the two sets of equations are not different from each other. We conclude from this exercise that whether we include aid/governance interaction term in the equation or not, aid to the agricultural sector has a significant positive effect on agricultural output in African countries. While this result is consistent with the conditional aid effectiveness hypothesis, it is also consistent with the unconditional aid effectiveness hypothesis. The result here is also consistent with the results of studies that find that institutional quality significantly improve agricultural production in African countries (Bates and Block 2013; Maruta, Banerjee, and Cavoli 2020; Ssozi, Asongu, and Amavilah 2019; among others).

In Panel B, the coefficient of *agraid* is positive and significantly different from zero at $\alpha = .05$ in all agricultural output equations. This is similar to the coefficient estimates presented in Table 3 above. The coefficient of the quadratic term of agricultural aid on the other hand is negative, small relative to the coefficient of the linear term, and significant at $\alpha = .05$ or better in all the agricultural output equations, suggesting the existence of diminishing returns to agricultural aid in this sample. χ^2 tests of equality between estimates of *agraid* in the linear and quadratic specifications in Tables 3 and 4, however suggests that there is no *qualitative* difference between the linear and quadratic specifications of the agricultural output equations.[12] Estimates of the linear specification model that exclude Egypt from the sample are presented in Panel C of Table 4. In Panel C, the coefficient of *agraid* is positive and significant at $\alpha = .05$ for all agricultural output equations. Apparently, our results that non-food agricultural aid has significant positive effects on agricultural output does not change when we exclude Egypt, a clear outlier in fertilizer use, from the sample.

The AMG estimates are presented in Panel D of Table 4. The long-run estimate of *agraid* is positive and significant at $\alpha = .05$ in all output equations. These estimates are similar in sign and absolute magnitude as their DCCE counterparts presented in Table 3. This may suggest that the effect *agraid* has on agricultural output is *qualitatively* the same whether we use the DCCE estimator or AMG estimator to estimate the q equation. Moreover, the estimate of the total factor productivity process in the AMG estimator is positive, relatively large, and close to unity and significantly different from zero at $\alpha = .05$, suggesting the existence of a TFP trend. The coefficient estimate of *agraid* as well as that of the common factors affirm the appropriateness of the DCCE estimator to estimate the agricultural output equation. The estimated long-run effects of *agraid* based on sys-DPD estimates of the q equation are presented in Panel E of Table 4. The estimates of *agraid* in all agricultural output equations is positive and significantly different from zero at $\alpha = .05$ or better. This suggests that the sys-dpd estimator may be an appropriate estimator for the agricultural output equation in this dynamic setting.

The estimates suggest that whether we use the DCCE, the AMG, or the sys-dpd, we find that agricultural aid has significant effect on agricultural output in African countries. The estimates, however, indicate that the sys-dpd estimates are generally marginally larger in absolute magnitude than their DCCE or AMG counterparts, suggesting the possibility of an upward bias in the sys-dpd estimates on account of not controlling for common factors. We conclude from

TABLE 4 | Agricultural Production: Alternative Specifications

Variable	*agvalwk*	*crpwk*	*lskwk*	*fdwk*	*cerealyd*
	(2)	*(3)*	*(4)*	*(5)*	*(6)*
Panel A:	**Conditional Agricultural Aid Effectiveness**				
agraid	0.2816***	0.2116***	0.3126***	0.2236***	0.2186***
	(3.24)	(3.71)	(3.46)	(3.00)	3.21
*agraid * gov*	0.0692**	0.0708**	0.0166***	0.0794**	0.0126***
	(2.73)	(2.70)	(2.66)	(2.62)	(3.08)
Panel B:	**Quadratic Specification**				
agraid	0.3214***	0.3749***	0.0.2894***	0.2004***	0.1863***
	(3.23)	(3.61)	(3.71)	(3.07)	(2.97)
$agraid^2$	-0.0017**	-0.0019**	-0.0019**	-0.0021**	-0.0112**
	(1.97)	(2.73)	(2.85)	(2.96)	(2.04)
Panel C:	**Sample Without Egypt**				
agraid	0.2043**	0.3012**	0.2051**	0.3656**	0.3698**
	(2.50)	(2.12)	(1.98)	(2.16)	(2.28)
Panel D:	**AMG Estimates**				
agraid	0.2197**	0.2461**	0.2924***	0.1996**	0.2009**
	(2.67)	(2.98)	(3.129)	(2.86)	(2.89)
Common Process	0.8120***	0.8621***	0.7821**	0.8219***	0.8719**
	(3.82)	(3.21)	(2.92)	(3.01)	(2.98)
Panel E:	**DPD-SYS Estimates**				
agraid	0.3607**	0.2382**	0.2015***	0.3279**	0.2816***
	(2.23)	(2.21)	(3.05)	(2.79)	(2.98)
N	585				

Dependent Variable: Agricultural Output
+ absolute value of "t" statistics in parentheses.
* 2-tail significance at $\alpha = 0.10$
** 2-tail significance at $\alpha = 0.05$
*** 2 tail significance at $\alpha = 0.01$

these exercises that our results that *agraid* has positive and significant effect on agricultural output does not depend on the way we specify the model or the estimator we use to estimate the agricultural output equation.

Our results are similar to the results of research that finds that agricultural aid has significant effects on agricultural output in recipient countries (Umbadda and Elgizouli 2018; Ssozi, Asongu, and Amavilah 2019; Madiou et al. 2020; Braughtigram and Knack 2015; Von Braun 2013); it is also consistent with studies that conclude that agricultural aid leads to increased growth in the agricultural sector, poverty reduction generally, and improved food security in recipient countries (Akpokodje and Umojimite 2008; Christiaensen, Demery, and Kuhl 2011; McArthur and Sachs 2018; Norton, Ortiz, and Pardey 1991; Mosley and Suleiman 2007; among others). The results are also consistent with the general aid effectiveness studies that find aid to have positive effects on development generally and agricultural output in particular. The results are generally inconsistent with the results of studies that conclude that agricultural aid does not have significant effect on agricultural output in recipient countries (Wonyra and Ametoglo 2020).

Xtdpdml Estimates

It is possible that our results that agricultural aid has significant positive effect on agricultural output crucially depend on the choice of a regressor that accounts for cross-sectional dependence to estimate the agricultural output equation. As another robustness check, we use the xtdpdml estimator to estimate the output equation to test this possibility. The results are presented in Table 5. As in Table 3, column 2 presents the estimates for *agvalwk*, column 3 the estimates for *crpwk*, column the estimates for *lskwk*, column 5 the estimates for *fdwk*, while column 6 presents the estimates for *cerealyd*. Regression statistics presented at the bottom of the table suggest that the xtdpdml estimator fits the data reasonably well and suggests that it can be used as an appropriate estimator for the q equation. We reject the null hypothesis that all slope coefficients are jointly equal to zero at $\alpha = .01$ level of significance.

The coefficient estimate of *agraid* for all output equations in Table 5 is positive and statistically significant at $\alpha = .05$ or better. The positive and statistically significant coefficient of *agraid* in all output measures in Table 5 suggests that our results that non-food agricultural aid has a significant positive effect on several measures of agricultural output does not depend on the use of DCCE estimator to estimate the agricultural output equation. However, the coefficient estimate of *agraid* in Table 5 is larger in absolute magnitude than their Table 3 counterparts. This may suggest that, like the dpd-sys estimator, the xtdpdml estimator imparts an upward bias to the effect of *agraid* on agricultural output. We note that the two sets of estimates are not strictly comparable because the DCCE estimates are composed of both short and long estimates while the xtdpdml estimates are not so classified. However, the sign and statistical significance of the two sets of estimates are *qualitatively* similar. We can therefore conclude from the estimates in Tables 3 and 5 that our conclusion that agricultural aid has significant positive effects on agricultural output does not depend on the estimator we use to estimate the q equation, although the magnitude to the estimated effects may be influenced by the choice of estimator.

The coefficient estimates of all control variables in Table 5 have the expected signs and similar to their counterparts in Table 3. With the exception of *fertcon* in the *crpwk*, *lskwk*, and *fdwk* equations, and of *tractor* in the *fdwk* equation,

TABLE 5 | Agricultural Production Equation: Xtdpdml Estimates

Variable	*agvalwk*	*crpwk*	*lskwk*	*fdwk*	*cerealyd*
	(2)	*(3)*	*(4)*	*(5)*	*(6)*
agraid	0.4023**	0.4583**	0.2921***	0.4478***	0.0342***
	(2.57)	(3.15)	(2.81)	(3.23)	(3.03)
irrigate	0.3372***	1.1398***	1.2133***	1.1623***	1.0089***
	(3.08)	(11.21)	(14.01)	(12.75)	(4.41)
tractor	0.0675**	0.0682***	0.0294***	0.0624	0.0728***
	(3.66)	(3.79)	(4.12)	(1.06)	(3.68)
polstab	0.28711***	0.2436***	0.2512**	0.2177***	0.0216***
	(3.54)	(4.46)	(2.64)	(3.54)	(3.21)
fertcon	0.0022***	-0.6991	-3.9912	-5.3889	0.4289**
	(4.11)	(1.28)	(1.12)	(1.22)	(2.86)
arable	3.4315***	57.6181***	46.1664**	50.4912***	150.29
	(2.89)	(3.24)	(2.45)	(3.05)	(1.00)
rain	0.4219***	0.2896***	0.3281***	0.2286***	0.5926***
	(3.86)	(4.29)	(3.39)	(3.89)	(3.02)
q_{t-1}	0.7592***	0.7621***	0.4892***	0.6718***	0.5928
	(12.80)	(12.76)	(13.22)	(11.09)	(9.08)
N	585				
Wald χ^2	378.92 398.90 [8]	[8]	33.70 [8]	28.52 [8]	26.98 [8]
$p-value$	0.00	0.00	0.00	0.00	0.00
RMSEA	0.02	0.04	0.04	0.05	0.02
$p-value$	0.00	0.00	0.00	0.00	0.00
AIC	7825.94	8762.09	6898.98	5697.65	
BIC	7992.98	9098.89	7289.09	6189.72	

Dependent Variable: Agricultural Output
+ absolute value of "t" statistics in parentheses.
* 2-tail significance at α = 0.10
** 2-tail significance at α = 0.05
*** 2 tail significance at α = 0.01

most of the coefficients are significantly different from zero at $\alpha = .05$ or better. As in Table 3, the coefficient of q_{t-1} is positive, relatively large and statistically significant at $\alpha = .01$. It is also significantly far less than unity, which suggests a stable relationship between agricultural output and the explanatory variables.

Components of Agricultural Aid

The estimates presented and discussed above indicate that total non-food aid to the agricultural sector has significant positive effects on agricultural output in African countries. Because agricultural aid comes in different components that may be earmarked for specific purposes, an important policy and research question is which component of agricultural aid leads to increased agricultural output. It is possible that different components of aid to the agricultural sector, such as aid for agricultural research, may be more effective in increasing agricultural output than other components. It is also possible that different components of agricultural aid may have different effects on different agricultural outputs. We investigate this possibility by using the various components of agricultural aid, instead of total agricultural aid as the regressor to estimate the agricultural output equations in this subsection.

The DCCE estimates of the long-run effects of the components of agricultural aid on various agricultural outputs are presented in Table 6. Column 2 presents the estimates for aid to agriculturalresearch (*agres*), column 3 the estimates for aid for agricultural education and training (*agedutr*), column 4 the estimates for aid for livestock development (*aglsk)*, column 5 presents the estimates for aid for agricultural management and development (*agdev)*, column 6 presents the estimates for aid to the provision of agricultural inputs (*aginp*), column 7 presents the estimates for aid for agricultural land development (*algr*), while column 8 presents the estimates for aid to

TABLE 6 | Long-Run Effects: Components of Agricultural Aid

Variable	*agres*	*agedutr*	*aglsk*	*agdev*	*aginp*	*algr*	*agwr*
	(2)	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
agvalwk	0.2035***	0.2068***	0.8703***	0.4147***	-0.4678*	0.4079	0.5459**
	(4.37)	(3.19)	(4.24)	(3.01)	(1.82)	(1.47)	(2.13)
crpwk	0.1214***	0.2359***	0.9986***	0.4224***	-0.7412	2.2678	0.5294**
	(3.42)	(3.14)	(3.06)	(3.42)	(0.47)	(1.12)	(2.31)
lskwk	0.2335***	0.1933***	1.3074***	0.3817***	-0.2106	4.7901	0.4998**
	(2.99)	(4.02)	(3.50)	(3.21)	(0.33)	(1.40)	(2.30)
fdwk	0.2454***	0.1585***	0.7051***	0.4396***	-0.5409	9.3894	0.8782**
	(4.31)	(3.55)	(3.98)	(4.01)	(1.67)	(1.41)	(2.24)
cerealyd	0.2186***	0.2641***	0.7612***	0.2891***	0.2109	0.6614	0.4868***
	(3.89)	(3.16)	(4.02)	(3.42)	(1.08)	(1.42)	(3.42)
N	585						

Dependent Variable: Agricultural Output
+ absolute value of "t" statistics in parentheses.
* 2-tail significance at $\alpha = 0.10$
** 2-tail significance at $\alpha = 0.05$
*** 2 tail significance at $\alpha = 0.01$

support agricultural water development (*agrw*).[13] Rows 1 through 5 of the table represent the various measures of agricultural output—*agvalwk, crpwk, lskwk, fdwk*, and *cerealyd* —we have used above. Each element in the table represents a unique effect a particular component of agriculture aid on a particular measure of agricultural output. For example, the intersection of *agres* and *agvalwk* represents the long-term effects of aid for agricultural research on per capita total agricultural value added, whereas the intersection of *agres* and *crpwk* represents the effect of aid for agricultural research on crop production per capita.

The coefficient estimates of *agres*, *agedutr*, *aglsk*, *agdev*, and *agwr* are positive and significantly different from zero at α = .05 or better in all agricultural output equations, suggesting that aid to support these activities significantly increases output in most agricultural subsectors. That aid to support these agricultural activities significantly increases agricultural output in African countries is not surprising since they complement, critically in some cases, domestic agricultural resources. These components of agricultural aid build agricultural "infrastructure" that have large positive externalities for the sector. We note that the effects of aid for livestock development (*aglsk*), agricultural administration and development (*agdev*), and for the development of irrigation and other agricultural water development (*agwr*) are generally much larger in all agricultural outputs than the effects of other components of agricultural aid. Perhaps, these aid components provide critical services for the agricultural sector and tend to have large positive externalities in African countries. On the other hand, the estimates show that *aginp* and *algr* have no significant longterm effect on agricultural output in our sample, suggesting that aid to support the purchase of agricultural inputs or land development have no long-term effects on agricultural output. It is also possible that the mechanism for allocating aid is not appropriate for the provision of inputs and land preparation. These aid components may not have large positive externalities and may be better left to be provided by the individual farmer through private markets.

Stads and Bientema (2015) argue that agricultural R & D and farmer education and training (extension services) are very critical for agricultural development in African countries and trace the slow development of agriculture in African countries to fluctuations and delays in aid to support agricultural research. For most African countries, agricultural aid is the only source of funding for agricultural R & D and extension services. Our results are consistent with this contention.

Our results have implications for agricultural aid policy and research. Besides increasing agricultural aid as a means of increasing agricultural output, the results suggest the need to target agricultural aid to specific activities where it may be more productive than spreading aid to all subsectors of agriculture. Our results not only suggest aid targeting, but also suggest specific areas, such as agricultural research, to target agricultural aid to activities that may have large positive externalities. Fortunately, donors have recognized the need to target agricultural aid in its delivery.[14] The results also indicate that the composition of non-food agricultural aid matter for aid effectiveness in the agricultural sector. While aid for some agricultural activities, especially those that may have large positive externalities, have significant positive effects on agricultural output, aid to support some agricultural activities do not have any significant effects on agricultural output. Knowing which activities to support is critical for ensuring agricultural aid effectiveness. For agricultural aid research purposes, our results suggest that it may be necessary for researchers to look at how various components of non-food agricultural aid affect agricultural production, hence the importance of disaggregating agricultural aid in studies of the effectiveness of agricultural aid.

Our results are consistent with the results of earlier research that finds that agricultural aid has a positive effect on agricultural output in African countries. However, our results differ from previous research in three different ways. First, we find that agricultural aid has both short- and long-run effects on agricultural output, results that previous research has ignored. Second, our study is the only one we are aware of that accounts for correlated factors across countries. Failure to account for these cross-country correlated effects could lead to biased estimates of aid effectiveness. Szozi Ssozi, Asongu, and Amavilah (2019) conclude that agricultural aid increases the output of export crop but decreases the production of food crops in African countries. We find no such "substitution" effects in our study. Finally, we find that the *composition* of agricultural aid matter for the effectiveness of agricultural aid. Previous research's focus on aggregate agricultural aid has not uncovered this important possibility. It is therefore important that researchers use disaggregated data in investigating the effects of aid on agricultural output.

Discussion

African economies have grown relatively fast over the last two decades at about an average of 5% per year resulting in increased per capita incomes. Growing per capita incomes and rapid population growth have resulted in increased demand for food. Unfortunately food production has not kept pace with increased demand resulting in increasing food imports. The relatively modest increases in food production have come as a result of acreage expansion as opposed to yield increases. Long-term increases in agricultural output may have to come from increases in yield, which is partly dependent on research, extension services, and other agricultural service infrastructure. Given that a large share of these services in Africa is financed from aid, our results show that foreign aid will continue to play an important role in the development of agriculture in Africa. However, not all components of agricultural aid are equally productive, suggesting the need for careful selection of agricultural aid instruments to recipients. Besides increased volume of aid, our results suggest that aid to the agricultural sector should be targeted to the provision of specific services such as research, extensions, and water—services that may have large positive externalities—rather than for the provision of services that have few externalities—such as the provision of inputs—that can be more efficiently provided by the private sector.

The aid policy implication of our results is the need for better targeting of agricultural aid, something that donors have recently recognized (Von Braun and Birner 2017; Cohen 2015; Todo and Takahashi 2013; Salazar et al. 2016; among others). In general, while it may be important to increase agricultural aid to Africa, our results indicate that what is more important than aid volume is the type of agricultural aid that is given to African countries. For research purposes, our results suggest the need for looking at aid in a disaggregated way not only at the sectoral level, but possibly at intra-sectoral levels in order to better capture the effect of aid on that sector. Our results also suggest the need to distinguish between short- and long-run effects of agricultural aid—something that previous research has not done. It is possible that aid may not have a short-run effect, but may have long-run effect; the reverse may also be true. Without investigating the short- and long-run effects, researchers may reach wrong conclusions.

We note that although agricultural aid significantly affect output in the agricultural sector, aid may only be a small component of factors that affect agricultural output in African countries. Increasing agricultural output in the long run in African countries will depend on appropriate domestic policies such as maintaining a stable macroeconomic environment, appropriate and competitive exchange rate and trade policies, market reforms, especially for agricultural inputs and outputs, and the development of rural infrastructure and institutional reforms in addition to increasing investment in agriculture (especially agro-processing) from domestic resources. However, African countries' investment in agriculture and rural development have been low and declining. While African countries set lofty goals of devoting 10% of central government budgets to agricultural investment at the Maputo Declaration (2003) and affirmed at the Malabo Declaration (2014), African countries have failed to come anywhere near these targets. Increasing agricultural output may require African countries to move closer toward these targets. Agricultural aid should therefore be seen as a catalyst, but not a panacea for solving Africa's agricultural output problems.

The results of our study should, however, be interpreted with caution. First, we provide only a reduced form relationship between non-food agricultural aid and agricultural output rather than a structural analysis. It is possible that a full structural model that accounts for the mechanisms through which agricultural aid affects agricultural output may not arrive at similar conclusion. Second, we do not provide any identification strategy, hence we cannot technically claim that the relationship we find can be interpreted as a causal relationship. Finally, several variables are poorly measured in our study and, given the quality of data and the fact that we used proxies for agricultural output indices to estimate the model suggest further caution in interpretation.

CONCLUSION

This paper uses panel data and a dynamic common correlated effects estimator to investigate the effects of non-food agricultural aid on agricultural output in African countries. Controlling for other variables, we find that increased total non-food aid to the agricultural sector is positively and significantly related to increased output in African countries both in the short and long run, regardless of how we measure agricultural output. This effect is robust to model specification, sample selection, and estimation method. However, the size of the effects depends on whether one controls for cross-country correlated effects in both output and inputs. In addition to the effect of total agricultural aid, we also find that various components of agricultural aid have significant positive effects on different components of agricultural output although the strength of the effect differ across measures of agricultural output and the components of agricultural aid. The results indicate that the composition of of agricultural aid matter for its effectiveness. The results are consistent with the results of studies that find a positive relationship between aid to the agricultural sector and agricultural output as well as those that find a positive effect of general aid on agricultural output. Our results have implications for both aid policy and aid research.

Although our approach to the study of the relationship between agricultural aid and agricultural output is different from those of previous research, our results are consistent with results of some of the earlier research that highlights the importance of agricultural aid for mediumto long-term agricultural development in low-income countries. Our results that the relationship between nonfood agricultural aid and agricultural output differ according to the particular activity supported by aid is an important addi-tion to the aid effectiveness literature. The results of our paper have policy as well as research implications.

NOTES

1. The set of agricultural outputs we analyze is dictated by the availability of complete data.

2. See WHO, *Vitamin and Mineral Nutrition Information System, VMNIS*, www.who.int/vmnis/en/.

3. See UN, International Trade Centre, *Trade Map*, various years.

4. See Chimhowu (2013) for more details on the flow of agricultural aid to sub-Saharan Africa.

5. An agricultural orientation index (AOI) of 0.67 implies that agriculture received only 67% of aid it should receive were it to receive aid commensurate with its importance in the economy.

6. Aid for rural development is classified as multi-sectoral because it may cover rural development projects that may be unrelated to agriculture, hence we do not study it here.

7. The components of *agraid* we present here is not exhaustive but limited by data availability.

8. The countries in the sample are: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Democratic Republic of Congo (DRC), Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Niger, Nigeria, Rwanda, Senegal, Seychelles, Somalia, South Africa, Togo, Uganda, Tunisia, Uganda, Zambia, and Zimbabwe. The sample used for this study are dictated by data availability.

9. This estimator is also called the maximum likelihood-structural equation modeling (ML-SEM) estimator.

10. We thank an anonymous referee of *this Journal* for drawing out attention to this point.

11. We only present the coefficient estimates of *agraid* for space consideration. The full estimates are available from the authors upon request.

12. Test statistics are not presented here due to space considerations.

13. We only present the estimates for the coefficients of the various components of aid to the agricultural sector. As in Table 4, we do not present regression statistics for the estimated equations for space considerations.

14. An example of such an approach is the US Feed the Future Program that focuses on specific interventions that increases farmer productivity.

REFERENCES

Akpokodje, G., and B. U. Omojimite. 2008. "The Effect of Aid Flows on Nigeria's Agricultural Growth." *Pakistan Journal of Social Sciences* 5 (6): 514–20.

Alabi, R. A. 2014. *Impact of Agricultural Foreign Aid on Agricultural Growth in Sub-Saharan Africa: A Dynamic Specification*. AGRODEP Working Paper 0006.

Bates, R. H., and S. A. Block. 2013. "Revisiting African Agriculture: Institutional Change and Productivity Growth." *The Journal of Politics* 75 (2): 372–84.

Brautigan, D., and S. Knack. 2015. "Foreign Aid, Institutions, and Governance in Sub-Saharan Africa." *Economic Development and Cultural Change* 52 (2): 255–85.

Chimhowu, A. 2013. *Aid for Agriculture and Rural Development in the Global South: A Changing Landscape with New Players and Challenges*. WIDER Working Paper No. 2013/014.

Chudik, A., and M. Pesaran. 2015. "Common Correlated Effects Estimation of Heterogeneous Dynamic Panel Data Models with Weakly Exogenous Regressors." *Journal of Econometrics* 188 (2): 393–420.

Chudik, A., K. Mohaddes, M. H. Pesaran, and M. Raiss. 2017. "Is there a Debt-threshold Effect on Output Growth?," *Review of Economics and Statistics* 188 (2): 393–420.

Christiaensen, L., L. Demery, and J. Kuhl. 2011. "The (Evolving) Role of Agriculture in Poverty Reduction: An Empirical Perspective." *Journal of Development Economics* 96: 239–54.

Cohen, M. J. 2015. "US Aid to Agriculture: Shifting Focus from Production to Sustainable Food Security." *Penn State Journal and International Affairs*: 99.

Dhahri, S., and A. Omri. 2020. "Does Foreign Capital Really Matter for the Host Country Agricultural Production? Evidence from Developing Countries." *Review of World Development* 156: 153–81.

Ditzen, J. 2019. *Estimating Long-Run Effects in Models with Cross-Sectional Dependence Using Xtdcc2.* CEERP Working Paper no. 7. Heriot-Watt University, Edinburgh, Scotland.

Eberhardt, M., and F. Teal. 2010. *Productivity Analysis in Global Manufacturing Production*. Economic Series Working Paper 5115, Department of Economics, Oxford University, Oxford, UK.

Food and Agricultural Organization. 2018. *Rapid Assessment of Aid Flows for Agricultural Development in Sub-Saharan Africa*. Investment Centre Division Discussion Paper, September, United Nations Food and Agricultural Organization.

Fugile, K. O., and N. E. Rada. 2013. *Resources, Policies, and Agricultural Productivity in Sub-Saharan Africa.* USDA Economic Research Report No. 145.

Kaysay, G. A., and L. G. Hansen. 2019. "The Effects of Climate Change and Adaptation Policy on Agricultural Production in Eastern Africa." *Ecological Economics* 121: 54–64.

Kaya, O., I. Kaya, and L. Gunter. 2008. "The Impact of Agricultural Aid on Agricultural Sector Growth." Paper presented at the Proceedings of the Southern Agricultural Economics Association Annual Meeting, Dallas, Texas, February 2–6.

———. 2013. "Foreign Aid and the Quest for Poverty Reduction: Is Aid to Agriculture Effective?" *Journal of Agricultural Economics* 64 (3): 583–98.

Kaya, O., and I. Kaya. 2019. "Aid to Agriculture and Aggregate Welfare." *Singapore Economic Review* 64 (2): 281–300.

Kherallah, M. W., J. C. Beghin, E. Peterson, and F. J. Ruppel. 1994. "Impacts of Official Development Assistance on Agricultural Growth, Savings and Agricultural Imports." *Agricultural Economics* 11 (2): 99–110.

Li, K., G. Cui, and L. Lu. 2020. "Efficient Estimation of Heterogeneous Coefficients in Panel Data Models with Common Shocks." *Journal of Econometrics* 216, 327–53.

Madiou, S., Y. J. Xue, A. Hussain, and L. Khanal. 2020. "Impact of Agricultural in Guinea of R&D Investment, Foreign Aid, and Climate Change." *North American Academic Research* 3 (1): 86–101.

Maruta, A. S., R. Banerjee, and T. Cavoli. 2020. "Foreign Aid, Institutional Quality and Economic Growth: Evidence from the Developing World." *Economic Modelling* 89 (2): 444–63.

McArthur, J. W., and J. D. Sachs. 2018. "Agriculture, Aid, and Economic Growth in Africa." *World Bank Economic Review* 33 (1): 1–20.

Mohammed, A. A., P. Rangkakulnuwat, and S. W. Paweenawat. 2016. "Decomposition of Agricultural Productivity Growth in Africa." *African Journal of Economic and Management Studie* 7 (4): 497–509.

Mosley, P., and A. Suleiman. 2007. "Aid, Agriculture and Poverty in Developing Countries." *Review of Development Economics* 11 (1): 139–58.

Norton, G. W., J. Ortiz, and P. G. Pardey. 1992. "The Impact of Foreign Assistance on Agricultural Growth." *Economic Development and Cultural Change* 40 (4): 775–86.

OECD. 2018. *Aid to Agriculture and Rural Development Data, 2018*. Paris, OECD Publications.

Pesaran, M. H. 2007. "A Simple Panel Unit Root Test in the Presence of Cross-Sectional Dependence." *Journal of Applied Econometrics*, 22: 265–312.

Rakotoarisoa, M. A., M. Iafrate, and M. Paschali. 2012. *Why Has Africa Become a Net Food Importer?* Rome, Food and Agricultural Organization.

Salazar, L., J. Aramburu, M. Gonzalez-Flores, and P. Winters. 2016. "Sowing for Food Security: A Case Study of Smallholder Farmers in Bolivia." *Food Policy* 65: 32–52.

Ssozi, J., S. Asongu, and V. Amavilah. 2019. "The Effectiveness of Development Aid for Agriculture in Sub-Saharan Africa." *Journal of Economic Studies* 46 (2): 284–305.

Stads J-J., and N. Bientema. 2015. "Agricultural R & D Expenditure in Africa: An Analysis of Growth and Volatility." *European Journal of Development Research* 27 (3): 391–406.

Todo, Y., and R. Takahashi. 2013. "Impact of Farmer Field Schools on Agricultural Income and Skills: Evidence from an Aid-Funded Project in Rural Ethiopia." *Journal of International Development* 25: 362–81.

Umbadda, S., and I. Elgizouli. 2018. "Foreign Aid and Sustainable Agriculture in Africa." In *Aid Effectiveness for Environmental Sustainability, edited by Y. Huang and U. Pascual*. Palgrave MacMillan, Singapore: Palgrave Macmillan.

Verter, N. 2017. "The Impact of Agricultural Foreign Aid on Agriculture in Nigeria." *Bulgarian Journal of Agricultural Sciences* 23 (5): 689–97.

Von Braun, J. 2013. *International Cooperation for Agricultural Development and Food and Nutrition Security: New Institutional Arrangements for Related Public Goods,* WIDER Working Paper No. 2013/061, Helsinki, WIDER.

Von Braun, J., and R. Birner. 2017. "Designing Global Governance for Agricultural Development and Food and Nutrition Security." *Review of Development Economics* 21 (2): 265–87.

Williams, R., P. D. Allison, and E. Moral-Benito. 2019. "Linear Dynamic Panel-Data Estimation Using Maximum Likelihood and Structural Equation Modeling." *The Stata Journal* 18 (2): 293–326.

Wonyra, K. O., and M. E. S. Ametoglo. 2020. "The Impact of Remittances on Agricultural Labor Productivity in Sub-Saran Africa." In *Palgrave Handbook of Agricultural and Rural Development in Africa*, edited by E. Osabouhein, 67–88. Singapore: Palgrave Macmillan.