The aid-nutrition link - Can targeted development assistance to the agricultural sector reduce hunger?

Lukas Kornher, Zaneta Kubik, Bezawit Beyene Chichaibelu

lkornher@uni-bonn.de

Zentrum für Entwicklungsforschung, Universität Bonn, Genscheralle 3, 53113 Bonn

GOOD GOVERNANCE IN DER EUROPÄISCHEN AGRARUMWELTPOLITIK: EINE INSTITUTIONENÖKONOMISCHE MEHREBENENANALYSE

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Abstract

In this study, we discuss and examine empirically the relevance of targeted ODA to the agricultural sector to improve food and nutrition security. Given the relationship between agricultural growth and poverty reduction as well as food and nutrition security, aid attributed specifically to the agricultural sector could have a stronger and more immediate impact than overall aid. We find a statistically significant and economically meaningful contribution of agricultural ODA to hunger and malnutrition reduction since 2000. This has important implications for donor countries that focus on the fight against hunger in their development cooperation strategies, such as Germany and its "One World without Hunger" initiative. To account for the potential reverse causality of aid and development outcomes, we follow the instrumentation approach of RAJAN AND SUBRAMANIAN (2008) and ARNDT ET AL. (2010) and apply it to sectoral aid using two novel zero-stage instruments.

Keywords

Foreign aid, hunger and malnutrition, aid effectiveness, agricultural ODA

1.Introduction

The literature on the effectiveness of official development assistance (ODA) at the macro level is as vast as controversial. The majority of the earlier studies focused on the effect aid has or might not have on economic growth (DALGAARD ET AL. 2000; EASTERLY 2003A, EASTERLY 2003B; HANSEN AND TARP 2001; RAJAN AND SUBRAMANIAN 2008; ARNDT ET AL. 2015). EASTERLY (2003A, 2003B) and later RAJAN AND SUBRAMANIAN (2008), who employ both cross-sectional instrumental variables (IV) and panel IV methods, find no statistically significant positive effect of foreign aid on economic growth. Easterly's main argument against aid is that aid planers do not know the preferences of the market actors in recipient countries. Consequently, aid distorts relative prices and sets wrong incentives (EASTERLY 2006). Aside from additional concerns, such as high transaction costs of aid, aid fragmentation, and proliferation, aid in form of general budget support is suspected of being used in ways not intended by the donor country when aid causes a sectoral reallocation of domestic resources. This observation is commonly referred to as aid fungibility, which could also limit the effectiveness of aid to support the (economic) development in the recipient country (DIELEMAN ET AL. 2013).

The empirical results of the abovementioned studies are contested by several studies (HANSEN AND TARP, 2001; JUSELIUS ET AL., 2013; LOF ET AL. 2015; ARNDT ET AL., 2015). For instance, HANSEN AND TARP (2001) use a dynamic panel model to account for the lagged effect of aid and show that aid had a positive, but at a decreasing rate, impact on economic growth. Arndt et al. (2015) look at the long-term effects of aid on growth, and the impact pathways, controlling for endogeneity. They find that aid impacts growth only in the very long-term (40 years) but not over shorter periods (ARNDT ET AL., 2010). The main impact pathway is through positive effects of aid on investment, public spending (consumption and investment), as well as education.

Subsequently, aid effectiveness was examined on sector-specific aid and several additional outcome variables, such as the impact on hunger and child nutrition (ARNDT ET AL. 2015; SSOZI 2019; MARY ET AL. 2018; 2020) and child mortality (MISHRA AND NEWHOUSE 2009). SSOZI (2019) examines the relationship between agricultural and rural development aid to agricultural productivity in Africa between 2002-2015. They detect that higher aid per agricultural worker was associated with increased output per worker in industrial food production but a decreased output in crop production. Recent empirical studies looking at the relationship between nutrition-sensitive aid and the prevalence of undernourishment (PoU) (MARY ET AL., 2018) as well as child stunting (MARY ET AL., 2020) suggest that agricultural aid improves food and nutrition security. Specifically, a 10 percent increase in overall nutrition-sensitive aid decreased PoU by 1.1 percent after two years during the period between 2002- 2015. Similarly, a 10 percent increase in agricultural aid per capita reduced child stunting by 0.5 percent (MARY ET AL., 2020). As a special case of agricultural and nutrition-sensitive aid, food aid is under the suspicion to boost food supply only in the very short-term but could have longer-term disincentive effects for agricultural producers in the recipient country (TADESSE AND SHIVELY 2009).

Taking a closer look at the nature of growth, it becomes apparent that certain sectors are key to improving food and nutrition security. The World's Poor and undernourished live predominantly in rural areas and are engaged in agriculture, fisheries, and forestry. In most countries of the Global South, the rural population traditionally relies on agriculture for its livelihood. The agricultural sector in these areas is characterized by smallholder farming, with 75 percent of the farms being smaller than two hectares (LOWDER 2016). Given these numbers, agricultural growth is more likely to be pro-poor and two to three times more effective in reducing poverty in low-income countries (CHRISTIAENSEN 2011; KLASEN 2017).

In addition to that, agricultural growth is directly linked to food and nutrition security because it increases food supply and generates income for the poor. An increase in domestic food production contributes to higher per capita caloric intake and lower poverty levels (Majid 2004; KAYA ET AL. 2013). In the agricultural sector, innovation leads to improved engineering and communication, which supports food production, develops biotechnology, and sets new platforms and institutional arrangements. Given the low level of agricultural productivity in LIMC (GOLIN ET AL. 2014), the achievement of high yield and labor productivity can be stimulated by increasing and sustained agricultural R&D (research and development) expenditures (Fuglie and Rada, 2011). Therefore, aid attributed specifically to the agricultural sector could have a stronger and more immediate impact than overall aid (KAYA ET AL., 2013). Macro studies are subject to a methodological shortcoming, since rigorous impact evaluation methods, such as randomized controlled trials, can only be employed to measure the effectiveness of specific aid projects but not at the country level without using a control group. The exercise becomes even more complicated as poorly performing countries, e.g. with high level of poverty and hunger, naturally attract more aid because of their low level of development (ADDISON ET AL. 2017).

Aside from discussions about the correct data handling process, the main critique of many macro studies is the identification strategy using time-series approaches and weak instrumentation of the general methods of moments (gmm) estimator. RAJAN AND SUBRAMANIAN (2008) introduce the idea of a strong external instrument based on estimates for the supply of aid by donor countries. We take up this idea to the specific case of agricultural and nutrition-sensitive aid. Specifically, we replicate the studies of ARNDT ET AL. (2010) and ARNDT ET AL. (2015), hereinafter AJT, to contribute to the literature on aid effectiveness and specifically on the association between agricultural aid and hunger. To account for the long-term effects of aid on all the sectors, which contribute to reducing food insecurity, different to the existing literature (SSOZI 2019; MARY ET AL. 2018; 2020), we focus on total agricultural aid flows between 2000-2017 and its association with hunger and malnutrition. Aid can influence food security through a range of direct and indirect transmission channels. We also add to the literature by investigating the associations between agricultural and nutrition-sensitive aid and food availability, accessibility and utilization. Given the controversial debate around aid effectiveness and to ensure that conclusions withstand scholarly critique, we provide full transparency about the data handling process, describe the instrumentation strategy in great detail, designate room for testing instrument validity à la AJT, and will make all underlying data and do files accessible.

The paper is structured as follows. Section 2 discusses the data, the methodological approach, and the instrumentation strategy in detail. Section 3 analyses the results. Section 4 provides a discussion of the results and concludes.

2. Methodology

2.1 ODA data and outcome variables

ODA is the bilateral and multilateral "government aid [without loans and credits for military purposes] designed to promote the economic development and welfare of developing countries" according to the OECD (2021) definition. The main data source of international aid contributions is the OECD's (Organization of Economic Cooperation Development) International Development Statistics. It encompasses data on bilateral aid flows from DAC (Development Assistance Committee) countries and multilateral aid flows channeled through international organizations through its Creditor Reporting System (CRS). The CRS provides also estimates for sectoral aid.

We emphasize that a narrow definition of aid allocations by a single sector is not very meaningful as there are cross-cutting effects and therefore aid is not always easily attributable to a specific sector. It is difficult to objectively and directly connect ODA allocations to food security initiatives and agriculture. Investment focus on long-term developmental efforts such as nutrition, rural infrastructure, and agricultural innovation can all in some ways positively impact food security and small-scale agriculture. Indeed, development cooperation projects always have wider effects beyond those related to their core and singular objectives, and similarly, such projects can rarely include in their budget the resources and activities to serve external purposes.

Considering the allocation challenges of ODA to any specific sector, and with respect to the context of this report, this study employs a definition developed by SCHWEGMANN ET AL. (2014) for food security and rural development ODA. This study adds the water and sanitation project categories to food security and rural development ODA following the growing body of evidence that indicates the important positive impact that access to safe drinking water, sanitation, and hygiene services have on nutrition. The definition relies on OECD sectoral ODA allocation data. Using the OECD purpose codes to identify the amount of ODA allocated to food security and rural development is critical in tracking and measuring the donor countries' spending in an internationally comparable way. The following categories are specified as pertinent for estimating the ODA contribution to food security and rural development (hereinafter agricultural aid): 1) Agricultural Development – OECD sector code 311; 2) Fishing – OECD sector code 313; 3) Forestry – OECD sector code 312; 4) Food Aid – OECD purpose codes 52010 and 72040; 5) Environmental Protection – OECD sector code 410 and purpose code 15250; 6) Rural Development – OECD purpose code 43040; 7) Water Supply and Sanitation – OECD purpose code 140. Due to the difficulty to attribute certain aid flows into specific categories, the aggregate of sector-specific aid is always substantially lower than overall aid. The relative share of agricultural aid (in overall aid) depends considerably on the donor country and has for some donor countries increased since 2000 (ZEF AND FAO 2020).

Besides the difficulty to attribute aid flows to specific sectors, donor countries report aid commitments, instead of actual aid flows, in the CRS. Therefore, it is important to use moving averages, instead of annual aid flows, to remove abnormal year-to-year fluctuations in aid commitments. In this study, we use three-year-moving averages. All aid data is in constant USD 2010 to make the values comparable over time. According to the OECD, data accuracy and completeness of CRS commitments for DAC members have improved over time from about 70 percent in 1995 to over percent in 2000 and nearly 100 percent after 2003. Therefore, we limit the analysis to data from 2000, which means, considering the moving averages used, that data between 2000-2017 is used in the analysis.

The main outcome variable in the empirical analysis is PoU. PoU is "the probability for the average individual in a population that habitual daily dietary energy consumption is below the requirements for a normally active and healthy life" (Conti 2020). The analytical computation relies on the assumption of a lognormal distribution of calorie supply, which is fitted based on estimated values of the average daily dietary energy consumption and its variation. The PoU is, therefore, a function of both the calorie supply per country per year as well as the purchasing power of the population modeled through household survey data (FAO ET AL. 2019). Different from Mary (2018), we examine the revised PoU data published only in 2020 (FAO ET AL. 2020). Three-year moving average PoU data is publicly available at FAOSTAT (2021). PoU data is available for every country but data is reported as "<1%" for countries with very low PoU levels. In this case, we replace PoU by 1 %.

We consider the change in per capita calorie supply, the change in per capita protein supply, the average level of year-to-year food price inflation, and the change in the per capita net food production index between 2000-2017 as immediate outcome variables describing the channels through which agricultural and nutrition-sensitive aid relates to hunger and nutrition. These four indicators are obtained from FAOSTAT (2021).

2.2. Estimation strategy

The econometric assessment is complicated due to two empirical elements. First, the relationship between aid and nutrition is structural which means that both aid and nutrition are related to several other variables, for instance, intermediate outcomes of aid, such as increasing agricultural productivity, better-functioning markets, or improved purchasing power. These nutrition effects of aid are not immediate but take time to fully unfold. In addition, aid is likely to have a cumulative and longer-term effect if it stimulates further investments. Therefore, focusing on the immediate short-term impacts of aid would neglect the impact it has on all the sectors that affect food insecurity in the medium or long-term. On the other hand, lower levels of development (e.g. poverty and hunger) are associated with higher aid flows, and thus, there is a reverse causality between aid and the outcome variables (ADDISON ET AL., 2017) which could cause an underestimation of the real effect size.

To account for the long-term nature of the expected relationship between ODA and PoU, and to address the former — intermediate vs. final outcome — problem, we estimate a reduced form model following RAJAN AND SUBRAMANIAN (2008) as well as AJT to avoid the need for instrumentation of each structural equation in a system of interrelated equations. Therefore, the reduced two-stage instrumental variable regression model appears as follows:

$$\begin{aligned} PoU_{(r,2017)} - PoU_{(r,2000)} &= \theta(Aid / pop_{(r,2000-2017)}) + \beta PoU_{(r,2000)} \\ &+\gamma(pcGDP_{(r,2017)} - pcGDP_{(r,2010)}) + \xi 'W'_{r} + u_{(r,t)} \end{aligned} \quad (1)$$

$$Aid / pop_{(r,2000-2017)} = \theta(SupplyAid / pop_{(r,2000-2017)}) + \beta PoU_{(r,2000)}$$
$$+\gamma(pcGDP_{(r,2017)} - pcGDP_{(r,2010)}) + \xi' W'_r + u_{(r,t)} \quad (2)$$

where Aid / pop refers to the average per capita annual agricultural ODA a recipient country received over the period 2000 to 2017 (3-year moving average) and Aid / pop are the fitted values generated by Equation 2. $SupplyAid / pop$ is the excluded instrument. We include the change in nominal $pcGDP$, the prevalence of undernourishment in 2000, and a set of country characteristics W'_r as control variables.

The reduced form approach requires a strong instrumentation strategy. Since the infant stages of the aid effectiveness literature, the instrumentation strategy was subject to debate. TAVARES (2003) proposes instrumentation based on the donor-recipient relationship informed by findings from earlier studies on the determinants of aid flows (e.g. ALESINA AND DOLLAR 2002). The idea to construct a single supply of aid instrument based on donors' aid spending follows the FRANKEL AND ROMER (1999) instrumentation strategy for trade and income. This approach requires proceeding in two steps. First, we estimate the supply of agricultural aid of each donor country to each recipient country, which we then aggregate at the level of the recipient country. The approach is described in detail in the succeeding section. Second, we estimate Equation (1) and (2) by two-stage least squares (2SLS)

We consider this instrumentation strategy for our purpose as superior over both internal instrumentation using gmm and alternative external instrumentation strategies, such as weather anomalies as proposed by BRÜCKNER (2013). Gmm instrumentation in a dynamic panel framework suffers from weak instrumentation, particularly if the data is non-stationary and/or persistent; which is both the case for PoU and other indicators of nutrition. Instrumentation based on weather anomalies is problematic for two reasons. On the one hand, it cannot be ruled out that extreme weather events in recipient countries induce larger aid flows — if not immediately, likely in the subsequent years. On the other hand, temperature and rainfall anomalies are correlated with intermediate outcomes of aid, and thus, aid and weather effects may become indistinguishable in the medium to long-run.

2.3. Construction of the instrument

To account for endogeneity by a single aid instrument as shown in Equation (1), we use the instrumental variable approach proposed by TAVARES (2003) and RAJAN AND SUBRAMANIAN (2008) taken up by AJT. The instrumentation strategy makes use of several specific characteristics of the ODA data and distinct motives of donor countries to giving aid to recipient countries (ALESINA AND DOLLAR 2002). Specifically, bilateral aid flow data provided by OECD's Creditor Reporting Standard allows modeling the supply-side characteristics of recipient specific aid allocations by individual donors.[1] As argued by AJT, we replace missing values by zeros. In doing so, we model the aid flow from country d to country r as follows:

$$SupplyAid / pop_{(dr,t)} = \beta_0 + \beta_1 COLONY_{dr} + \beta_2 \log\frac{pop_{(d,2000)}}{pop_{(r,2000)}} + \beta_3 Colony_{dr} \times \log\frac{pop_{(d,2000)}}{pop_{(r,2000)}} \quad (3)$$
$$+\beta_4 COMLANG_{dr} + \beta_5 COMCONT_{dr} + \lambda' DIPLO'_{dr,2000} + FE_d + u_{(dr,t)}$$

[1] Missing aid flow values are treated as zeros.

The selection of the instruments in Equation (3) was subject to extensive debate (CLEMENS AND BAZZI 2009; ARNDT ET AL. 2010). We do not use metropole dummies, like RAJAN AND SUBRAMANIAN (2008), as they have been shown to be potentially endogenous. COLONY (a dummy variable taking the value of one if the recipient country was ever a colony of any country), COMLANG (a dummy variable taking the value of one if the recipient country uses the same language as the donor), $\log \frac{pop_{(d,2000)}}{pop_{(r,2000)}}$ (the ratio of the initial population size of donor and recipient), and FE_d (donor fixed effects) are the AJT instruments. However, these instruments appeared to have much less explanatory power to describe bilateral agricultural aid flows in the period 2000-2017 than they had in the earlier studies that look at overall aid (see Table 1). Therefore, we included two additional instruments; first, COMCON (a dummy variable taking the value of one if the donor country and the recipient country are from the same continent); and second, a set of dummy variables describing the level of diplomatic representation of the donor country at the recipient country in 2000 (chargé d'affaires, ambassador or others). The variables are constructed based on data obtained from CEPII (HEAD ET AL. 2010, 2014) and the Diplomatic Exchange Data of the Correlates of War project (BAYER 2006).

Table 1 reports the regression results using three different estimators: Ordinary Least Squares (OLS), Poisson Pseudo Maximum Likelihood (PPML), and the two-step maximum likelihood estimator of a Heckman Selection model (Heckman). A parsimonious OLS model based on donor fixed effects only, presented in Column 1, explains below than 10 percent of the variation in bilateral agricultural aid flows. In Column 2, we employ the preferred zero stage regression of AJT — we exclude the dummy variable for a current colonial relationship as it does not apply to our sample in the observation period — which explains close to 12 percent of bilateral agricultural aid flows, as compared to 21 percent of bilateral overall aid flows between 1970-2000 (ARNDT ET AL. 2010). In Column 3, we show our preferred specification with additional instruments. All instruments account for about 14 percent of the variation in the OLS model. To account for the large number of zero aid flows, and possible selection processes, we also employ the PPML estimator and the two-stage Heckman selection model. We cannot reject the independence of outcome and selection model in the Heckman selection model at conventional levels of statistical significance but at a 15 percent margin of error. Therefore, we choose the PPML estimator as our preferred specification. In all models in Columns 3-5, we observe that the coefficient estimate of the new instruments are statistically significant and improve the predictions of bilateral aid flows. Last, Column 6 reports the results of the PPML estimator for bilateral overall aid flows between 2000-2017. Similar to what the comparison of Column 2 with AJT revealed, we do observe that the predictions of bilateral overall aid flows are more precise than bilateral agricultural aid flows.

It is important to note, that the results in Table 1 are not the first stage instrumental variable estimates and $SupplyAid / pop_{(dr,t)}$ is not the final instrument. Instead, the final single generated aid instrument is constructed by aggregating the predicted bilateral aid flows $Aid / pop_{(r,2000-2017)} = \sum_{d=1,\dots,n} SupplyAid / pop_{(dr,t)}$ each recipient receives across all its donors. When constructing the aggregated aid instrument based on the OLS estimation, we replace negative predictions of bilateral aid flows by zero. We discuss the validity of the excluded zero stage instruments and the single generated aid instruments in great detail below. For this purpose, we follow AJT and create aggregated instruments from the zero-stage instruments. Namely, the mean of the initial population ratio (log), a dummy if the recipient country was ever a colony, the interaction of the two, a dummy if the recipient country shares a common language with at least one donor country, a dummy if the recipient country is on the same continent with at least one donor, and last, the recipient country's share of donors' diplomatic representation.

Table 1: Zero-stage regressions of bilateral aid flows between 2000-2017

	Determinants of bilateral aid flows					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	OLS	**OLS**	**OLS**	**PPML**	**Heckman**	**PPML**
Colonial relationship		0.217***	0.197***	2.003***	0.410*	1.416***
(dummy)		(0.0609)	(0.0620)	(0.311)	(0.221)	(0.446)
Ratio of initial log.		0.0301***	0.0492***	0.456***	0.134***	0.638***
population		(0.00367)	(0.00451)	(0.0421)	(0.014)	(0.0489)
Ratio of initial log.		0.0093	0.00265	-0.270***	-0.069	0.0936
Population x colony		(0.01663)	(0.0169)	(0.0730)	(0.059)	(0.0676)
Common language		0.0376	0.0177	-0.219	0.153	-0.411*
(dummy)		(0.0251)	(0.0259)	(0.212)	(0.158)	(0.248)
Common continent			0.123***	0.588***	0.159***	0.813***
(dummy)			(0.0228)	(0.156)	(0.061)	(0.155)
Diplomatic relationship (dummies)						
Chargé d'affaires			0.161***	1.577***	0.437**	-0.323
			(0.0480)	(0.446)	(0.188)	(0.534)
Ambassador			7.747**	1.295***	0.677**	1.226***
			(2.631)	(0.160)	(0.344)	(0.143)
Other			0.143***	0.797*	0.486	1.123***
			(0.0196)	(0.425)	(0.324)	(0.401)
Dep. variable	Agric aid/pop	Agric aid/pop	Agric aid/pop	Agric aid/pop	Agric aid/pop	Overall aid/pop
Outcome and selection independence					0.923	
Donor FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,411	3,274	3,094	3,038		3,047
R-squared	0.087	0.117	0.143	-	-	-
Pseudo R-squared	-	-	-	0.32	-	0.76

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. We included a dummy variable for countries in sub-Saharan African and Latin American countries but omitted the coefficient estimates for the sake of space. We excluded small states and countries that were classified as fragile and conflict-affected states by the World Bank.

Source: Authors' elaboration.

3 Results

3.1 Reduced form results

The single generated aid instrument, in all its variants presented in Table 1, fulfills instrument relevance with F-statistics beyond 30 confirming its relevance. The results of the instrumental variable regression for the long-term drivers of PoU are reported in Table 2. Column (1) presents the OLS estimator without considering endogeneity, Columns 2-4 present the results of the 2SLS regressions estimated by limited information maximum likelihood (LIML), Column 5 presents the 2SLS results using the six aggregated individual zero-stage instruments, and last, Column 6 reports the 2SLS regression results for overall, instead of sectoral aid, using the instrument from Table 1 Column 6. In line with expectations, the coefficient of agricultural aid is negative in all specifications. The coefficient estimate for agricultural aid is statistically insignificant using the OLS estimator and statistically significant at, at least 10 percent level of significance, in all other specifications, including the specification in Column 5 employing six zero-stage instruments. The difference in the coefficient estimates in the OLS and 2SLS estimations highlights the importance to employ an instrumentation strategy. Both the weak identification statistic and the Anderson Lagrange Multiplier Test do not contest the validity of the chosen 2SLS specification. The point coefficient of around 0.210 implies that an increase in average per capita agricultural ODA by US$ 1 was associated with a reduction in PoU by 0.21 percentage points. Given that the per capita agricultural ODA between 2000-2017, among the sample countries was, on average, US$ 10.2, and increased by about 20% (in constant US$ 2010), agricultural ODA has significantly contributed to the reduction of PoU since 2000, specifically by averagely about 2.1 percentage points. About half of the recipient countries received between US$ 2-13 per capita (pc), including Ghana (US$ 11 pc), Uganda (US$ 10 pc), and Ethiopia (US$ 10 pc). Some countries with significant progress in the reduction of hunger, such as Myanmar and Angola, on the other hand, received only 2.6 USD pc and 5.8 USD pc, respectively. Increasing agricultural aid in these countries could reduce hunger more significantly due to the diminishing returns of aid.[2]

Table 2: Instrumental variable regression for change in PoU between 2000-2017

	Change in PoU between 2000-2017					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	OLS	**IV-LIML**	**IV-LIML**	**IV-LIML**	**IV-LIML**	**IV-LIML**
Agricultural aid/pop	-0.126	-0.219**	-0.214*	-0.213*	-0.273**	
2000-2017[3]	(0.0868)	(0.111)	(0.113)	(0.128)	(0.124)	
Overall aid/pop						-0.0265
2000-2017						(0.0196)
ΔGDP per capita	-0.00159***	-0.00175***	-0.00175***	-0.00174***	-0.00185***	-0.00159***
2000-2017	(0.000469)	(0.000459)	(0.000460)	(0.000472)	(0.000474)	(0.000448)
PoU 2000	-0.510***	-0.501***	-0.501***	-0.502***	-0.495***	-0.510***
	(0.0748)	(0.0704)	(0.0703)	(0.0706)	(0.0716)	(0.0702)
Constant	8.471**	10.53***	10.43**	10.39**	11.74***	8.625**
	(3.955)	(4.062)	(4.081)	(4.298)	(4.227)	(3.901)
Instruments	-	1	1	1	6	1
Zero-stage	-	OLS	PPML	Heckman	-	PPML
Endogeneity		0.2155	0.2552	0.3777	0.1227	0.4241
Weak id. statistic		68.361	64.158	39.896	32.487	111.095
Anderson LM		0.0000	0.0000	0.0000	0.0000	0.0000
Anderson-Rubin statistic					3.203	
Sargan statistic					3.131	
Observations	70	70	70	70	70	70
R-squared	0.60	0.59	0.59	0.59	0.58	0.59

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The regressions include the State Fragility Index in 2000, the coastal population density, and the tropical area of tropical of the recipient country as controls. We included a dummy variable for sub-Saharan African, South Asian, and Latin American countries but omitted the coefficient estimates for the sake of space. We excluded small states and countries that were classified as fragile and conflict-affected states by the World Bank.

Source: Authors' elaboration.

In addition, we not as ascertain a similar relationship between overall aid and PoU. Precisely, the coefficient estimate, which is about a tenth of the coefficient estimate for agricultural aid, suggests that the leverage in reducing hunger is substantially greater using targeted aid than overall aid. The coefficient estimates of our main control variables, change in per capita GDP and PoU in 2000 are statistically significant at one percent. To confirm the robustness of the results, we run the same model using a linear-log specification for per capita agricultural aid, the average agricultural ODA relative to the GDP, as well as, agricultural and nutrition-sensitive aid following MARY ET AL. (2018) as aid indicator. All alternative specifications confirm the results from Table 1.

[2] To account for the possibility of diminishing returns to aid, we also estimate a linear-log model. The corresponding coefficients of 1.78 implies that additional 10% of agricultural aid (which corresponds to averagely 1USD) was associated with a reduction in PoU by 0.18 percentage points.

[3] We always use a 3-year moving average of the ODA data to smooth out discrepancies between aid commitments and actual aid flows.

In addition, we employ two robust estimators as suggested by AJT, namely the inverse probability weighted least squares (IPWLS) and the inverse probability weighting regression adjustment as a flexible alternative. To use the IPWLS and IPWRA estimators we need to create a dichotomous aid instrument dividing the sample in treated (countries with larger ODA inflows measured by the supply of aid instrument) and control (countries with smaller ODA inflows) countries. The results of the IPWLS and IPWRA estimations in Table 3 confirm the results of 2SLS LIML approach, however, the level of significance and the coefficient estimate appear sensitive to the cut-off point between treated and untreated countries.

Table 3: Doubly robust estimator results for change in PoU between 2000-2017

	IV-IPWLS		IV-IPWRA	
	ATE	ATET	ATE	ATET
Treated=50, Untreated=20	-4.439*** (1.639)	-4.302** (1.656)	-4.416*** (1.448)	-4.354*** (1.514)
Treated=45, Untreated=25	-3.846** (1.609)	-3.919** (1.685)	-3.851*** (1.387)	-3.949*** (1.481)
Treated=40, Untreated=30	-1.874 (1.588)	-2.010 (1.583)	-2.268^{+} (1.493)	-2.670^{+} (1.632)
Treated=35, Untreated=35	-1.982 (1.605)	-2.591^{+} (1.626)	-2.178^{+} (1.478)	-2.947* (1.710)

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1, $^{+}$ p<0.15. All controls from Table 2 are included but omitted. We included a dummy variable for sub-Saharan African, South Asian, and Latin American countries but omitted the coefficient estimates for the sake of space. We excluded small states and countries that were classified as fragile and conflict-affected states by the World Bank.

Source: Authors' elaboration.

3.2 Instrument validity

Given the significant weight associated with the instrumentation strategy in this study, we carefully test instrument validity. There are two main concerns expressed in the literature: weak instrumentation and overidentification, particularly the potential correlation of the initial population ratio with the outcomes variables. The results of the 2SLS regression in Table 2 (Column 5) confirm the relevance of the zero-stage regression instruments as excluded instruments in the first stage. In Column 1 of Table 2, we show that they jointly explain 82 percent of the variation in the generated supply of aid instrument. We test for overidentification of the aggregated zero stage instruments and present the associated Anderson-Rubin chi2 statistics in Table 2 Column 4. The statistic is 3.13 and therefore we cannot reject instrument validity. Overidentification cannot be tested for the single generated aid instruments as the first stage regression is just identified.

Further, we follow AJT and test the exclusion restriction of the predictor variables by regressing the error term of the instrumental variable regression on instruments. None of the coefficient estimates in Column 2 is statistically significant. Last, we report the difference-in-Hansen J test statistic when excluding each zero-stage instrument individually from the 2SLS regression. Indicated by the respective probabilities in Column 3, none of the instruments fail the difference-in-Hansen test. From the results of the instrumental variable regression, the error regression, and the difference-in-Hansen tests presented in Column 2-3 below, we conclude that there is no evidence for a problem with the exclusion restriction associated with neither of the individual instruments of the zero-stage regression.

Table 4: Instrument validity checks

	Fitted coefficients (1)	Residual coefficients (2)	C stat. (Prob.) (3)
Initial pop. Ratio (log)	0.4097***	0.1867	0.036 (0.85)

Colony (ever)	-0.1079	-0.9910	0.218 (0.64)
Initial pop. Ratio (log) x Colony	-0.0734	-0.9742	0.764 (0.38)
Common language	-0.1277	0.1508	0.008 (0.93)
Common continent	0.6839***	-2.327	0.580 (0.45)
Number of ambassadors	0.0250	-5.540	1.493 (0.22)
R-squared	0.82	0.04	

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. We included a dummy variable for countries in sub-Saharan Africa and Latin American as well as fragile and conflict-affected states but omitted the coefficient estimates for the sake of space. We also controlled for the change in the level of improved access to water and sanitation in the regression but do not show the coefficients. We excluded small states and countries that were classified as fragile and conflict-affected states by the World Bank.

Source: Authors' elaboration.

4 Discussion and Conclusions

In this study, we discuss and examine empirically the relevance of targeted ODA to the agricultural sector to improve food and nutrition security. The conceptual discussion presents evidence that targeted aid could be more effective and acts more immediate than overall aid in settings in recipient countries with high rural poverty and greater importance of the agricultural sector. Overall, the regression results confirm the conceptual discussion on the potential impact of agricultural ODA on hunger and child malnutrition and the findings of MARY ET AL. (2018) and MARY ET AL. (2020). Specifically, we find a statistically significant and economically meaningful contribution of agricultural ODA to hunger and malnutrition reduction since 2000. The coefficient estimates are not comparable to the estimates provided in the literature given that those are based on short-term fluctuations in ODA, while we examine the aggregate impact of agricultural ODA over 18 years. Over this period, we do not find a statistically significant impact of overall ODA on food and nutrition security. This is in line with the findings by ARNDT ET AL. (2010), who show that overall ODA was statistically significant only after about 40 years, and highlights the importance of agricultural ODA to achieve short-run improvements in hunger and malnutrition reduction. This has important implications for donor countries that focus on the fight against hunger in their development cooperation strategies, such as Germany and its "One World without Hunger" initiative.

Overall, we contribute to the growing empirical evidence on the effectiveness of agricultural ODA. We complement the findings of MARY ET AL. (2018) and SSZOI ET AL. (2019) employing dynamic panel models and MARY ET AL. (2020) who apply a different instrumentation strategy. Therefore, we also make a methodological contribution that contributes to the empirical falsification in this strain of literature.

For the sake of brevity, we did not include the results on potential impact pathways. Employing the identical instrumentation strategy, we find that agricultural ODA was statistically significantly associated with improvements in per capita calorie supply and lower levels of food price inflation. We ascertain a negative association between agricultural ODA and changes in the food production index and a positive but not statistically significant association between per capita protein supply and agricultural ODA. These potentially heterogeneous results on different dimensions of food security deserve subsequent analysis in future studies.

There are also caveats associated with this study. Sectoral aid allocations in the CRS are not complete since ODA is not always attributable to a specific sector. Therefore, our definition of agricultural ODA may have omitted aid flows relevant to food and nutrition security in the recipient countries but not reported under the OECD sector codes considered in our definition. In addition, and due to the reporting problem, we cannot conclude which type of agricultural aid could contribute to what extent to hunger-reduction. Last, we have only provided estimates of the long-term association, namely about 20 years, but did not investigate the dynamics of the effects.

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