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What effect does development aid have on productivity in recipient countries?

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Abstract

Development aid does not always positively impact economic growth. Instead, aid may decrease total factor productivity (TFP) and discourage the recipient country's own effort to grow. This study contributes to research on macroeconomic aid transmission channels by using panel data from 51 recipient countries over a 36-year period and applying panel time-series techniques. The main aim is to study the aid–productivity relation by analyzing the impact of different forms of aid (grants; loans; and bilateral, multilateral, and sector-related aid) on productivity while accounting for institutional factors and economic policy. The analysis controls for endogeneity and autocorrelation to ensure consistent and efficient estimates. To examine possible vicious circles often attributed to aid, we run quantile regressions to determine the role of aid across productivity quantiles. We find evidence that aid reduced TFP through grants and bilateral aid from 1972 to 1999 and in all quantiles of the TFP distribution from 1972 to 2009. We also find differences in the impact of sector-related aid, where aid is harmful in more productive countries.

KEYWORDS

development aid, TFP growth, time-series approach, quantile regressions

JEL CLASSIFICATION

C18; C21; F35; O4; O11

1 | INTRODUCTION

There has been intense academic debate on the effectiveness of development aid and its impact on economic growth. Many studies do not find a positive effect of aid on aggregate economic growth per capita (Doucouliagos & Paldam, 2009, 2010, 2013; Herzer et al., 2015; Nowak-Lehmann et al., 2012; Rajan & Subramanian, 2008). However, another strand of literature argues that aid does indeed have a positive impact on economic growth (Arndt et al., 2015; Hansen & Tarp, 2001; Juselius et al., 2013; Lof et al., 2015; Mekasha & Tarp, 2013; Tarp et al., 2013). Most results suggest that if there is an effect, it is limited (see Arndt et al., 2009, for a comprehensive overview).

The ineffectiveness of aid to contribute to economic growth could be explained by counteracting effects of aid on different channels of growth, that is, investment, saving, human capital, and total factor productivity (TFP). Because aid influences different channels of growth, simultaneously, the positive and negative effects might be neutralized. While some studies show that development aid has a very small but positive and significant impact on investment (Alvi & Senbeta, 2012; Doucouliagos & Paldam, 2006; Nowak-Lehmann et al., 2012; Nowak-Lehmann & Gross, 2021), this effect is counteracted by an appreciation of the real exchange rate (Nowak-Lehmann et al., 2012; Rajan & Subramanian, 2011) and a crowding-out of domestic savings (Nowak-Lehmann et al., 2012). Aid in the education sector has been found to effectively increase at least primary education enrollment (Dreher et al., 2008; Riddell & Niño-Zarazúa, 2016), thus improving economic growth in the long run.

In addition to the macroeconomic effects associated with aid, poor institutions, governance, (Bräutigam & Knack, 2004), and economic policy (Burnside & Dollar, 2000, 2004) might impair aid from positively affecting growth. Some studies have found that aid increased corruption (Ali & Isse, 2003; Djankov et al., 2008) by strengthening the predatory power of the government. In contrast, Tavares (2003), Okada and Samreth (2012), and Selaya and Thiele (2012) found that aid reduces corruption because the grant component of aid improves bureaucratic quality. The general failure of aid to become effective has been examined by Easterly (2003) and Easterly et al. (2003) following up on the damaging effect of aid on economic incentives.

In this paper we investigate a neglected channel as a contributor to economic growth: TFP. Very few studies focus on the impact of aid on TFP, but TFP can affect all components of economic growth because it captures factors such as innovation, education, efficiency in allocation and use of resources, and institutions and infrastructure (Kim & Loayza, 2019; Kim et al., 2016). In one study, Alvi and Senbeta (2012) focus on the aid–productivity relation and found that aid distorts financial conditions and leads to an inefficient allocation of financial resources to less-efficient projects and, therefore, has a productivity-diminishing effect. The study finds that although multilateral aid stimulates investment, grants and bilateral aid have a dampening effect on TFP growth. Therefore, the negative impact of aid on TFP reduces the overall positive effect of aid on growth.

The aim of this study is to analyze how and to what extent development aid influences TFP and its growth in recipient countries over longer periods of time. This study investigates whether aid at the lower or higher end of the TFP distribution or different forms of aid have a different effect on recipient countries. To the best of our knowledge, and apart from the study by Alvi and Senbeta (2012), the aid–productivity transmission channel is still under-researched, even though TFP is an important source—if not *the* most important source—of economic growth (Baier et al., 2006; Case lli, 2005; Easterly & Levine, 2001). As it is possible that countries along the productivity distribution react differently to net aid inflows (be it grants or loans or multilateral or

bilateral sector-related aid), we perform quantile regressions following Delgado (2008), Marzban (2008), Kleiber (2010), Canay (2011), and Baum (2013).

The variable TFP growth is derived as the residual of growth accounting and measures the income growth per worker not attributable to factor accumulation, including physical capital, labor, and human capital. Thus, TFP growth measures a combination of changes in efficiency in the use of capital and labor inputs, along with changes in technology (Bosworth & Collins, 2003). Changes in efficiency are reflected through better quality inputs, better functioning markets, and better institutions.

We investigate the causal nexus of aid and productivity through different types of aid. A productivity-enhancing impact can be expected if aid supports projects that benefit the whole economy, for example, by investing in education, health, infrastructure, communication, and bureaucratic quality. We study different forms of aid, namely the aggregate net Official Development Assistance (ODA) as a combined variable, and also its components: grants and loans, multilateral and bilateral assistance, and sector-related aid. We collected sector-related aid data from the AidData database that reports ODA disbursements based on the OECD. Stat Creditor Reporting System (CRS) and its respective purpose codes (Tierney et al., 2011).

Our empirical results indicate that aid measured as ODA negatively affects TFP growth, with grants and bilateral aid being the most ineffective types of aid. This result is driven by the 1973–1999 period. All quantiles of the TFP distribution are negatively affected by grants and bilateral aid, with no statistically relevant differences across quantiles. In addition, aid categorized as sector related seems to further lower TFP. However, this phenomenon is observed only at the higher quantiles of the TFP distribution. For lower quantiles, the impact of sector-related aid is insignificant.

This study is structured as follows: Section 2 briefly reviews the theoretical and empirical literature on the determinants of productivity. Section 3 describes the data for the general empirical model used to quantify the impact of aid on productivity. Section 4 derives the empirical TFP model from a multiplicative theoretical model. Section 5 presents our general results from the dynamic feasible generalized least squares (DFGLS) method and quantile regressions. Section 6 concludes.

2 | LITERATURE REVIEW

TFP is measured as the residual in a growth-accounting framework that disaggregates gross domestic product (GDP) growth or firm outputs by its components: growth in capital stock; change in human capital stock; and the residual, productivity, or TFP. TFP is usually calculated by a production function of different forms in cross-country or cross-firm-level studies. The residual is found to be large, explaining most of the cross-country and cross-time difference in output growth (Baier et al., 2006; Caselli, 2005; Easterly & Levine, 2001). But what drives changes in TFP?

The theoretical literature on the drivers of sustainable growth of output and productivity is still shaped by seminal research from the 1980s and 1990s. Lucas (1988) and Romer (1990) focused on the role of human capital for long-run growth, while Grossman and Helpman (1991) emphasized the role of innovation. Similarly, Jones and Williams (1998) and Hall et al. (2009) analyzed the returns to investment in research and development (R&D). Taking an open economy perspective, Rivera-Batiz and Romer (1991) and Krugman and Venables (1998) emphasized the importance of economic integration and specialization for economic growth and productivity.

In a more recent paper, Stokey (2015) developed a theoretical model explaining stagnating or low growth rates as the result of the interaction between technology inflow and human capital accumulation, keeping countries in a stagnation steady state with constant (low) factor levels.

Two recent papers summarize the main empirical drivers of TFP as innovation, education, efficiency in the allocation and use of resources, institutions, and infrastructure (Kim & Loayza, 2019; Kim et al., 2016). Empirical research in industrialized countries has analyzed the role of trade openness (Kose et al., 2009); human capital (Benhabib & Spiegel, 1994; Bronzini & Piselli, 2009; Erosa et al., 2010; Griffith et al., 2004); financial openness and foreign direct investment (FDI) (Keller & Yeaple, 2003); technology, foreign multinational companies, and R&D (Cameron et al., 2005; Comin, 2004; Griffith et al., 2003); and the impact of information and communication technologies (ICTs) (Basu et al., 2004; Colecchia & Schreyer, 2002) on productivity growth.

Kose et al. (2009) turned their attention to the interplay between de facto and de jure financial openness and TFP. Keller and Yeaple (2003) focus on the contribution of trade and FDI to TFP and find that there are technological spillovers from both FDI and imports but that those from FDI are economically more pronounced. Emphasizing the role of technology, Comin (2004) and Cameron et al. (2005) examined and confirmed the role of R&D in terms of productivity. Griffith et al. (2003) found that technology transfers and TFP performance are supported by the presence of high-productivity foreign multinational companies that accelerate technology convergence and generate productivity increases in national branches. These studies are complemented by Colecchia and Schreyer (2002) and Basu et al. (2004), who examined the impact of ICTs. Education and its effect on human capital are considered as other determinants of TFP. Indicators such as years of schooling and populations' level of secondary and tertiary education affect growth directly through human capital accumulation and indirectly via improving TFP by making the factor human capital more productive (Benhabib & Spiegel, 1994; Bronzini & Piselli, 2009; Erosa et al., 2010; Griffith et al., 2004). Overall, most of the studies mentioned here have analyzed the determinants of TFP growth in developed countries. Consequently, there is a need to understand productivity growth in developing countries where R&D, ICTs, and financial markets are underdeveloped, meaning that other determinants of TFP will drive changes.

Not much is known about development aid as a determinant of TFP growth, although TFP is one of the fundamental transmission channels through which development aid is assumed to trigger economic growth (Alvi & Senbeta, 2012; Hansen & Tarp, 2001).

Hansen and Tarp (2001) find little evidence that aid directly impacts growth. Instead, they find that aid indirectly affects growth through increased investment. They suspect a weak negative effect of aid on TFP but do not empirically test the impact. Alvi and Senbeta (2012) investigate the aid–investment–TFP nexus by calculating 5-year averages of TFP growth (resulting in seven observations per country) from an aggregate production function using the system generalized method of moments (GMM) estimation approach.[1] They measure aid as net ODA as a share of GDP using 5-year averages[2] and consider subcategories of ODA such as multilateral and bilateral aid, grants, and loans. The study finds that ODA, bilateral aid, grants, and loans have an insignificant impact on TFP growth. Aid does indeed stimulate investment, but simultaneously it has a dampening effect on TFP through multilateral aid disbursements. According to the authors, aid undermines the efficacy of financial institutions by subsidizing less-productive projects. Herzer and Morrissey (2013) point to the indirect effects of aid on growth through aggregate productivity. They show that the impact of aid on productivity can be negative if aid exacerbates growth-retarding factors such as poor governance. The study by Economides et al. (2008) supports these findings by showing that aid increases rent-seeking behavior[3] and changes individual incentives

to invest in activities that cause social destruction, thereby harming economic growth, especially when the public sector is large. All studies discussed here use data from the Penn World Tables (see footnote 8).

We add to the literature by shifting the focus on the impact of development aid on productivity in the long run[4] using time-series methods (checking the time-series properties and applying cointegration techniques). This implies that we estimate the regressions only when the left-hand and right-hand time series are in a long-run relationship, that is, when they are systematically related and in a long-run equilibrium (cointegrated) from 1973 to 2009 (Banerjee et al., 1993; Granger & Newbold, 1974). Finding cointegration reduces the omitted variable problem and serves as a medium of defense against spurious regressions (Pedroni, 2007). TFP is explained by a multiplicative model, which reflects the fact that TFP is a product of nonadditive and inseparable factors such as aid, policy, and institutions. In addition, we use quantile regression analysis to investigate whether countries along the productivity distribution react differently to net aid inflows (be it grants or loans or multilateral, bilateral, or sector-related aid). This allows us to identify the types of aid that are most harmful in low-, intermediate-, or high-productivity countries.

3 | DATA AND SOURCES

Our data on TFP was provided by Barry Bosworth (Brookings Institution, Washington, D.C.) and we appreciate it. TFP growth is measured as a residual in a growth-accounting framework using 1972 as base year[5] and assumes a production function with constant returns to scale (Bosworth & Collins, 2003). The Bosworth data set contains indicators for GDP growth, TFP growth, capital accumulation, growth of the labor force, and growth of human capital (years of schooling) for 84 countries from 1960 to 2008.[6] The Bosworth data set covers only the formal economy but still has some advantages[7]: first, the estimates of growth rates are based on figures in constant national prices guaranteeing some stability of the figures[8]; and second, the data uses a "first-best" measure of capital stock, based on national prices constructed by Nehru and Dhareshwar (1993). As an indicator for aid level, we use six different variables: we measure aid as the combined net ODA; we disaggregate aid into its components of grants and loans to observe differences in the form of aid disbursement; we measure the share of multilateral and bilateral aid to observe differences in the channels of aid distribution; we use sector-related aid based on CRS and its respective purpose codes (see Table 1) to analyze aid that is relevant for productivity. All the aforementioned categories of aid are computed as shares of GDP.

The variables that we include in the analysis to control for factors that might affect productivity[9] are institutional quality (from the Freedom House Index that starts in 1973) and macroeconomic performance and economic policy indicators (openness, inflation, and fiscal policy) taken from the World Bank's World Development Indicators database (World Bank, 2015), based on studies such as Rajan and Subramanian (2008). The final sample contains a panel of 51 developing countries from Africa, Asia, and Latin America for the period from 1973 to 2009.[10] Table 2 provides an overview of all variables used in the analysis, descriptive statistics, and number of observations. The detailed variable descriptions and data sources are presented in Table A1. The list of countries is provided in Table A2.

The aid-related variables in Table 2 show that ODA as a share of GDP is, on average, 7.7% among aid receivers. Grants contribute more to ODA than loans, reported as gross loans. Aid in the form of bilateral aid constitutes a higher proportion of GDP than aid through multilateral channels. Sector-related aid amounts to less than 1% of GDP.

TABLE 1 CRS purpose codes for sector-related aid

CRS codes	Description
11,110–111,430	Aid for education
12,110–12,281	Aid for health
15,110–15,170	Aid for government and civil society
21,010–21,081	Aid for transport and storage
22,010–22,040	Aid for communication
23,010–23,082	Aid for energy generation
24,010–24,081	Aid for banking and financial services
25,010–25,020	Aid for business and other
31,110–31,191	Aid for agriculture, forestry, and fishing
32,110–32,182	Aid for industry
32,310	Aid for construction
33,110	Aid for trade policy and adjustment
33,210	Aid for tourism

Abbreviation: CRS, Creditor Reporting System.

Source: OECD (2016).

TABLE 2 Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
TFP index (level)	93.70499	93.31921	193.5169	36.20635	23.09625	1,506
TFP growth	−0.067292	−0.055048	0.701674	−0.87561	0.230524	1,506
Trade	65.40859	53.70964	412.1636	6.320343	47.02892	1,506
Inflation	47.64173	9.708016	11,749.64	−9.808765	401.7231	1,506
Government consumption/GDP	13.47012	12.43989	43.47921	2.047121	5.424422	1,506
Freedom House Index	1.856574	2.000000	3.000000	1.000000	0.678585	1,506
Capital–labor ratio	1.710599	0.091663	40.31894	0.000000	5.730632	1,506
ODA/GDP	0.077898	0.024921	1.306377	−0.005651	0.115779	1,789
Grants/GDP	0.062063	0.015688	1.289095	0.000194	0.108595	1,789
Gross ODA loans/GDP	0.029044	0.012911	0.408490	0.000000	0.039401	1,789
Multilateral aid/GDP	0.027847	0.006567	0.428043	−0.006165	0.045930	1,789
Bilateral aid/GDP	0.050052	0.016920	0.976893	−0.005842	0.081491	1,789
Sector-related aid/GDP	0.006542	0.000266	0.350437	0.000000	0.019847	1,789

Abbreviations: GDP, gross domestic product; ODA, Official Development Assistance; TFP, total factor productivity.

The TFP index is constructed from annual TFP growth rates obtained from the growth-accounting procedure following Bosworth's method. The index has been set to 100 in the base year (1972), and follow-up values were calculated using annual TFP growth rates (see footnote 11 for an explanation of the computation methodology). Figure 1 shows the index values over time. Note that only countries receiving development aid are included. Cyprus and Turkey experienced TFP growth, followed by Mauritius, India, and Thailand. Overall, countries in Asia and Europe

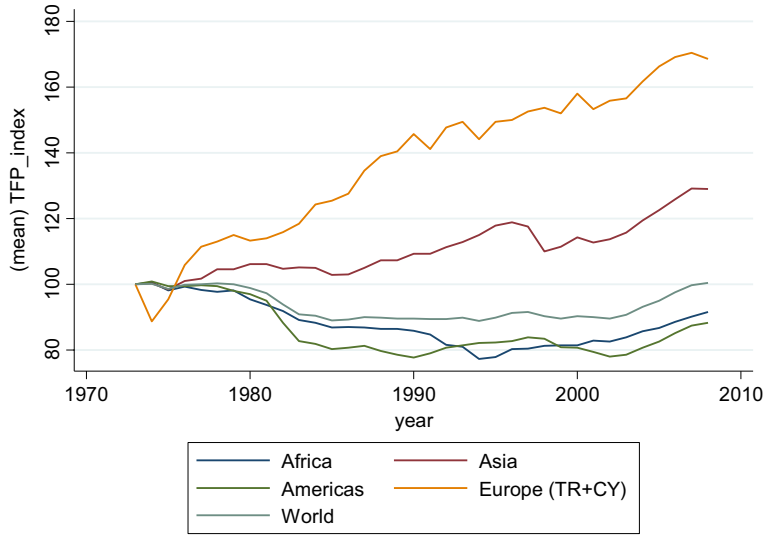

FIGURE 1 TFP (total factor productivity) index development over time and continents of ODA recipients. *Source*: Authors' own calculation [Colour figure can be viewed at wileyonlinelibrary.com]

have had positive TFP growth, while countries in Latin America and Africa have had negative TFP growth, defined as being less than the global average. The average TFP growth in Table 2 is negative, indicating that, on average, productivity negatively contributed to economic growth rates overall in ODA-receiving countries.

4 | EXPLAINING TFP AND TFP GROWTH: THE EMPIRICAL MODEL

4.1 | Deriving the estimation equations

The level of TFP in an economy is influenced by a multitude of factors, including macroeconomic factors, economic policy, institutions, and level of technology and development aid. We assume that productivity drivers (X) impact productivity multiplicatively, with their impact being nonseparable.

$$TFP_{it} = a_i \prod_{k=1}^{K} X_{kit}^{b_k} e^{u_{it}}. \tag{1}$$

The subscript i refers to country ($i = 1, ..., I$), and t ($t = 1, ..., T$) is the time. TFP_{it} is the *level* of TFP in each country at a certain point in time. X_k, where $k = 1, ..., K$, are explanatory variables, that is, the factors that enhance or impede productivity.

By log-linearizing Equation 1, we obtain a log–log model with the TFP level on the left-hand side shown in Equation 2 as follows:

$$\ln TFP_{it} = \ln a_i + \sum_{k=1}^{K} b_k \ln X_{kit} + u_{it}. \tag{2}$$

Given that TFP levels are not directly observable, the dependent variable is computed as an index value (called ln_TFP_index) for the empirical analysis. We begin by setting the TFP index value to 100 for each country in the base year (1972) and compute the follow-up values by using the annual country-specific TFP growth rates, which have been obtained by Bosworth's growth-accounting procedure.[11]

The factors that are chosen to represent X are various economic indicators to be discussed. *Economic policy* is an instrument that can increase efficiency, most probably in the short or medium run. In the related literature, economic policy is approximated using three subcomponents: trade openness, inflation rate, and government consumption as a percentage of GDP (Burnside & Dollar, 2000, 2004). We hypothesize that *openness* has a positive impact on productivity as it promotes competition for producers of goods for export and import. However, it may have a negative impact if it diverts producers of tradable goods from engaging in export production due to a lack of infrastructure and/or access to ICTs. *Inflation* (at least beyond a certain threshold) is considered to reduce efficiency, as it is unclear to economic agents whether increasing prices are caused by supply scarcities, are good investment prospects, or are a purely monetary phenomenon (excess money compared to output). In turn, lower levels of inflation might indicate that an economy is growing and signal dynamism. *Government consumption as a percentage of GDP* can influence productivity in both directions: while it may be negative if it causes a crowding-out effect of private activity and disincentives private efforts, it could also have a positive impact on productivity if the government undertakes tasks in areas with no private investment.

Institutional quality is regarded as a long-term determinant of productivity, as it influences multiple factors such as corruption, rule of law, and general investment climate. We hypothesize that better institutional quality has a positive impact on productivity. In this study, *institutional quality* is approximated by the Freedom House Index, as it covers a longer time span. The index ranges from one (free) to three (not free), with higher values representing poorer institutional quality.

The *capital–labor ratio* is considered an indicator of technology levels. We consider technology as a "key" factor for TFP and hypothesize that higher capital–labor ratios promote productivity.

For measures of *development aid*, we include net ODA (as a share of GDP), grants (as a share of GDP), loans (as a share of GDP), multilateral aid (as a share of GDP), bilateral aid (as a share of GDP), and sector-related aid (as a share of GDP). The role of aid for productivity as it relates to TFP growth has received little attention in the literature. The expected impact of aid on productivity is indeterminate because the direction of the effect is unclear. On the one hand, aid might increase TFP growth by financing and attracting additional investment. On the other hand, aid might distort incentives and reduce efficiency by leading to an overvalued real exchange rate, thus damaging the production of tradable goods.

The regression equation for TFP growth[12] can be derived from Equation 2 by subtracting lagged ln TFP from both sides of Equation 2. We obtain Equation 3 and have TFP growth rate $g_{it} = \ln TFP_{it} - \ln TFP_{i,base}$ on the left-hand side. Equation 3 shows that the current rate of TFP growth is determined by its past level (path dependency). Equation 3 could be estimated by replacing $\ln TFP_{i,baseyear}$ by $\ln(K/L)_{i,baseyear}$ as data for the TFP level is not yet available. We consider the *capital–labor ratio* (of the base year) provided in the Bosworth data set as the "second-best" proxy for TFP level in the base year, but this variable will be absorbed in the country-fixed effects:

$$g_{it} = \ln TFP_{it} - \ln TFP_{i,base} = \ln a_i + \sum_{k=1}^{K} b_k \ln X_{kit} - \ln TFP_{i,base} + u_{it}. \quad (3)$$

Base refers to base year. The results on the determinants of TFP growth (*TFP_growth_1972* that has been calculated backward) are presented in Tables A6–A8.

4.2 | Using time-series-based estimation techniques

Before running regressions, we test the time-series properties of our series (see Table A3) and test whether the time series are cointegrated, that is, in a long-run relationship (see Table A4). We find evidence that the time series is nonstationary and cointegrated. An important implication of finding cointegration is that no relevant integrated variables are omitted in the cointegrating regression. Therefore, finding cointegration is an effective control against spurious regressions and omitted variable bias as the residuals, which are stationary in the presence of cointegration, do not contain omitted variables or omitted interaction effects that are able to affect *tfp,* which is nonstationary (Herzer & Nunnenkamp, 2012; Pedroni, 2007). In addition, given that we find endogeneity[13] and autocorrelation in our regressions, we employ estimation techniques that control for those problems when estimating the equations both on the mean and in the quantiles of the TFP distribution. We also test for cross-sectional dependence of the error terms (Table A5). The Pearson CD Normal test points to cross-sectional dependence. Therefore, to account for it, we apply the White cross-section method.[14] This estimator assumes that the errors are contemporaneously correlated (period clustered) and is robust to cross-equation (contemporaneous) correlation and heteroskedasticity (Arellano, 1987; Wooldridge, 2002).

$$tfp_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \ln X_{kit} + u_{it}. \tag{4}$$

tfp_{it} represents either the TFP level ($\ln\_TFP\_index_{it}$) or TFP growth (g_{it}). α_i are country-fixed effects and account for all factors, which are time invariant and country specific, to control for unobserved heterogeneity.

4.2.1 | Regressions on the mean of TFP distribution

In the first stage, Equation 4 is estimated using Equation 5. This technique is called the dynamic ordinary generalized least squares (DOLS) approach. DOLS requires all time series to be nonstationary and in a long-run equilibrium.[15] DOLS controls for the endogeneity of all right-hand-side variables by adding the variables in first differences and the leads and lags of the first differences (Wooldridge, 2012).[16] Heteroscedasticity is addressed by computing robust standard errors:

$$tfp_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \ln X_{kit} + \sum_{\substack{p=+1 \\ p=-1 \\ k=1}}^{\substack{K \\ \\ \\}} \chi_{k,p} \Delta \ln X_{kit-p} + v_{it}, \tag{5}$$

with $p \in \{-1; 0; +1\}$. The lag number p can be determined by the akaike information criterion (AIC) information criterion.

In the second stage, we save the residuals $\hat{v}_{it}$ from Equation 5 and use the DOLS estimation method and then compute the autocorrelation coefficient to address the autocorrelation of the error terms. The autocorrelation coefficient is determined by regressing $\hat{v}_{it}$ on its past values; that is, $\hat{v}_{it} = \hat{\rho} \cdot \hat{v}_{it-1}$, leading to $\hat{\rho}$. $\hat{\rho}$ is obtained by estimating an OLS model. All left-hand- and right-hand-side variables are now transformed (characterized by an asterisk) as follows:

$$\begin{array}{lll} tfp^*_{it} = tfp_{it} - \hat{\rho} \cdot tfp_{it-1} & \alpha^*_i = (1-\hat{\rho}) \cdot \alpha_i & v^*_{it} = v_{it} - \hat{\rho} \cdot v_{it-1} \\ \ln X^*_{kit} = \ln X_{kit} - \hat{\rho} \cdot \ln X_{kit-1} & \Delta \ln X^*_{kit} = \ln X^*_{kit} - \ln X^*_{kit-1} & \text{for all } k \end{array} . \tag{5a}$$

It should be emphasized that the new error term $v^*_{it} = v_{it} - \hat{\rho} \cdot v_{it-1}$ does not show characteristics of autocorrelation. In the third stage, a regression is run on the transformed variables shown in Equation 6 using the DOLS procedure:

$$tfp^*_{it} = \alpha^*_i + \sum_{k=1}^{K} \beta_k \ln X^*_{kit} + \sum_{\substack{p=+1 \\ p=-1 \\ k=1}}^{K} \chi_{k,p} \Delta \ln X^*_{kit-p} + v^*_{it}. \tag{6}$$

The combination of FGLS (second- and third-stage procedures) and DOLS is called dynamic feasible least squares and leads to consistent and efficient estimates.

4.2.2 | Regressions for different quantiles of TFP distribution

As it is possible that countries along the productivity distribution react differently to net aid inflows (be it grants or loans, multilateral or bilateral aid, TFP-related aid), quantile regressions are a useful tool to capture the heterogeneity of countries with different levels of productivity and to further extend the analysis.[17] Therefore, we examine countries at different positions of the TFP (growth) distribution by estimating quantile regressions in the $\tau \in \{0.10; 0.25; 0.50; 0.75; 0.90\}$ quantiles. Since quantile regressions were originally developed for cross-sectional studies with a common intercept, we adjust the approach for use with panel data (Canay, 2011) and allow for the correction of endogeneity and autocorrelation, which is not possible in the standard quantile regression setup. We recognize that by applying an FGLS procedure (Cochrane–Orcutt procedure) to correct for autocorrelation, and simultaneously we solve the fixed effect problem. Having very high autocorrelation coefficients ($\hat{\rho}$) in all regressions,[18] the fixed effect problem is taken care of by transforming all the variables entering the regressions.[19] Again, we must generate quasi first differences for all variables (left-hand side and right-hand side) entering the regression equation. The transformed variables (characterized by an asterisk) enter Equation 7, and endogeneity is taken care of by adding the first differences (also leads and lags) as before.

The quantile regression is estimated as follows:

$$\hat{\beta}(\tau) = \min_{\beta} \left\{ \frac{1}{I \cdot T} \sum_{T=1}^{T} \sum_{i=1}^{I} \left| tfp^*_{it} - X'^*_{it} \beta \right| \right\} \tag{7}$$

$$\text{with } X_{it}'^{*}\beta = \sum_{k=1}^{K} \beta_k \ln X_{kit}^{*} + \sum_{k=1}^{K} \sum_{p=-1}^{p=+1} \chi_{k,p} \Delta \ln X_{kit-p}^{*}.$$

5 | RESULTS

Regressions are based on 51 countries with annual data from 1973 to 2009. We examine the determinants of productivity, to answer two research questions: first, whether different types of aid (grants and loans,[20] bilateral and multilateral aid, and sector-related aid) have a different impact on TFP levels or work differently in the different quantiles of the TFP distribution (Tables 3 and 4) and on TFP growth (Tables A6 and A7); and second, whether aid has a different impact during different time periods (Table 5).

5.1 | Are there differences in the impact of different types of aid?

The disincentive effects of development aid have been pointed out by Easterly (2003) and Moyo (2009). Aid has a negative impact when, because of receiving aid, governments reduce their own expenditures through revenues and/or when households and firms in recipient countries regard aid as an alternative to their own savings as a source of financing investments. We assume that grants reduce productivity and that loans increase productivity, since investments funded by loans are chosen more carefully due to interest payments and loan repayment. We have no strong evidence[21] on the effectiveness of multilateral versus bilateral aid, even though donor self-interest might be lower with multilateral aid, and thus, this type of aid might be more development oriented. As for sector-related aid flowing into economic and social infrastructure, we hypothesize that its impact on productivity is positive and therefore enhances productivity.

Table 3 shows that trade openness and capital–labor ratio, the latter being our indicator for technology, always have a positive and significant impact on TFP. The rate of inflation and the deterioration of institutions (i.e., an increase in the Freedom House Index) usually have a negative impact on TFP, while government consumption has a positive impact. The coefficients are not always significant, but the signs of the coefficients are compatible with our expectations.

When studying the impact of aid on TFP levels (with ln_TFP_index as the dependent variable, see column 1 of Table 3), we find supporting evidence for most of our hypotheses. We observe that net ODA diminishes TFP. The impact is negative and insignificant when running regressions on the mean (Table 3) but negative and (mostly) significant when later running regressions for the quantiles (Table 4, column 3). A 1% increase in net ODA reduces the TFP level by approximately 0.02% in the latter case. Net ODA has a negative and significant impact on TFP levels in all quantiles of the distribution (except the highest quantile), with a diminishing negative impact on higher quantiles. However, quantile slope tests show that differences in the impact across quantiles are not statistically significant.

When differentiating between grants and loans (Table 3, column 2), we find that grants have a negative and significant impact on TFP levels, when performing estimations on both the mean and the median. A 1% increase in grants reduces the TFP level by approximately 0.02%–0.04%. Grants negatively impact all quantiles of the TFP distribution (Table 4), but there are no statistically significant differences between the different quantiles. The impact of loans is insignificant, and the same holds for all quantiles.

TABLE 3 The impact of aid on TFP level—DFGLS estimation

	1	2	3	4
	ln TFP index	ln TFP index	ln TFP index	ln TFP index
ln_net_ODA	−0.007			
	(0.006)			
ln_grants		−0.021*		
		(0.012)		
ln_loans		−0.001		
		(0.006)		
ln_multilateral ODA			−0.004	
			(0.006	
ln_bilateral ODA			−0.017**	
			(0.008)	
ln_sector-related ODA				0.005
				(0.005)
ln_trade openness	0.079***	0.074***	0.075***	0.095***
	(0.021)	(0.021)	(0.023)	(0.030)
ln_inflation	−0.011***	−0.010***	−0.007*	−0.009
	(0.003)	(0.003)	(0.004)	(0.006)
ln_government consumption (as % of GDP)	0.0017	0.021	0.036*	−0.003
	(0.019)	(0.018)	(0.022)	(0.029)
ln_freedom house index	−0.023	−0.014	−0.017	0.006
	(0.016)	(0.015)	(0.018)	(0.016)
ln_capital–labor ratio	0.083**	0.045*	0.109***	0.138***
	(0.042)	(0.045)	(0.043)	(0.068)
Constant	4.364***	4.386***	4.413***	4.456***
	(0.138)	(0.132)	(0.139)	(0.209)
Observations	1,175	1,193	1,047	650
Endogeneity control (one lead and one lag)	Yes	Yes	Yes	Yes
Autocorrelation control (FGLS)	Yes	Yes	Yes	Yes
Country-fixed effect	Yes	Yes	Yes	Yes
Cross-sections	50	50	50	47
R^2	0.980	0.982	0.981	0.988
Durbin–Watson statistic	1.803	1.835	1.874	1.794
Autocorrelation coefficient (AR(1))	0.944	0.940	0.943	0.856

Notes: DFGLS estimation: control for autocorrelation via FGLS; control for endogeneity via DOLS; White cross-section standard errors are in parentheses; ***$p < .01$, **$p < .05$, and *$p < .1$.

Abbreviations: DFGLS, dynamic feasible generalized least squares; DOLS, dynamic ordinary generalized least squares; GDP, gross domestic product; ODA, Official Development Assistance; TFP, total factor productivity.

TABLE 4 The impact of aid on different quantiles of the TFP-level distribution

	1	2	3	4	5		
	Q.10	**Q.25**	**Q.50**	**Q.75**	**Q.90**	**Observations**	**Pseudo R^2**
ln_net_ODA	−0.025*	−0.024***	−0.019***	−0.016**	−0.015	1,175	0.103
	(0.014)	(0.009)	(0.008)	(0.008)	(0.009)		
ln_grants	−0.034	−0.036***	−0.037***	−0.032***	−0.037***	1,193	0.111
	(0.022)	(0.011)	(0.009)	(0.009)	(0.009)		
ln_loans	−0.005	−0.001	0.004	0.004	0.006	1,193	0.111
	(0.009)	(0.008)	(0.006)	(0.007)	(0.008)		
ln_multilateral ODA	−0.019	−0.004	0.005	0.008	−0.004	1,047	0.113
	(0.012)	(0.006)	(0.005)	(0.006)	(0.009)		
ln_bilateral ODA	−0.040***	−0.037***	−0.035***	−0.028***	−0.021***	1,047	0.113
	(0.009)	(0.009)	(0.008)	(0.008)	(0.012)		
ln_sector-related ODA	−0.010	−0.004	−0.018**	−0.029***	−0.030***	650	0.100
	(0.008)	(0.006)	(0.008)	(0.007)	(0.010)		

Notes: Regressions are performed with the least absolute distance method. An approach based on the DFGLS procedure is used to control for endogeneity and autocorrelation. The coefficients of the control variables are not reported but available on request. Huber-Sandwich standard errors are used. Gray shades refer to statistically different slope coefficient across quantiles.

Abbreviations: DFGLS, dynamic feasible generalized least squares; ODA, Official Development Assistance; TFP, total factor productivity.

TABLE 5 The impact of aid on the level of TFP before and after 2000—DFGLS estimation

	Period: 1973–1999			Period: 2000–2009		
	Aid coefficient	**Observations**	**R^2 adjusted**	**Aid coefficient**	**Observations**	**R^2 adjusted**
ln_net_ODA	−0.006	860	0.97	−0.016	315	0.99
	(0.007)			(0.011)		
ln_grants	−0.027*	869	0.97	−0.0158	324	0.99
	(0.015)			(0.014)		
ln_loans	−0.001	869	0.97	−0.005	324	0.99
	(0.007)			(0.005)		
ln_multilateral ODA	−0.005	785	0.97	0.012	262	0.99
	(0.007)			(0.139)		
ln_bilateral ODA	−0.019*	785	0.97	−0.009	262	0.99
	(0.011)			(0.005)		
ln_sector-related ODA	−0.009	325	0.98.	0.004	325	0.99
	(0.055)			(0.007)		

Notes: DFGLS estimation (same procedure as in Table 3): control for autocorrelation via FGLS; control for endogeneity via DOLS; White cross-section standard errors are in parentheses; ***$p < .01$, **$p < .05$, and *$p < .1$. The coefficients of the control variables are not reported but available on request. Included control variables: ln_trade openness, ln_inflation, ln_government consumption (as % of GDP), ln_freedom house index, ln_capital-labor ratio, and country-fixed effects. DFGLS = dynamic feasible generalized least squares.

Abbreviations: DOLS, dynamic ordinary generalized least squares; GDP, gross domestic product; ODA, Official Development Assistance; TFP, total factor productivity.

Making a distinction between multilateral and bilateral aid, Table 3 (column 3) and Table 4 show an insignificant impact of multilateral aid (i.e., it does not harm productivity) and a clear negative and significant impact of bilateral aid (i.e., a 1% increase in bilateral aid reduces TFP by approximately 0.02%–0.03%). The negative impact of bilateral aid decreases at higher quantiles, but statistically significant differences between quantiles cannot be found. Multilateral aid is insignificant for all quantiles.

Sector-related aid (Table 3, column 4), the most promising aid category, has either an insignificant impact (running regressions on the mean) or a negative, significant impact on TFP (running regressions on the median; Table 4, column 3). Sector-related aid seems to harm the 0.50, 0.75, and 0.90 quantiles, and when the difference between quantiles is tested, these differences are significant.

Since Figure 1 suggests that TFP growth rates started to increase in 2000, we estimate the impact of net ODA and its subcomponents separately for the period 1973–1999 and 2000–2009 (see Table 5). We obtain interesting results when working with two time periods. The negative impact of grants and bilateral aid remains in the period 1973–1999 but disappears after 2000. Therefore, the overall finding is that neither net ODA nor its subcomponents have a significant impact on the development of TFP, in particular since 2000.

A possible explanation for aid's diminishing negative impact on TFP is that this phenomenon coincided with changes in donor practices (OECD, 2003) in the early 2000s resulting from the Millennium Development Goals and initiatives in research to evaluate the impact of development aid, see upcoming research in the 2000s by Esther Duflo, Abhijit Banerjee, Michael Kremer and Paul Glewwe and others (Banerjee et al., 2007; Duflo & Kremer, 2003; Glewwe & Miguel, 2007). Harmonizing donor practices and activities in their operational policies, procedures, and sectoral projects could have improved the effectiveness of development assistance and its impact on productivity. At the sectoral level, project monitoring and evaluation evolved and might have improved the efficiency of development projects with greater government ownership of public sector policy and allocation of resources.

Comparing our results with Alvi and Senbeta (2012), we confirm the overall insignificant impact of ODA on TFP but disagree on the role of grants, loans, and bilateral and multilateral aid. However, these divergent results might be explained by some differences in the analysis (the importance of cointegration versus neglect of cointegration) and estimation techniques. In contrast to Alvi and Senbeta (2012), who use average 5-year TFP growth rates, we use yearly TFP levels or TFP growth since 1972 as a robustness check. Both of our dependent variables are nonstationary (I(1)) and cointegrated with the right-hand-side variables, which guarantees nonspurious regressions. Using annual data instead of 5-year averages leaves us with more observations and therefore more information. Regarding the estimation technique, we use DFGLS instead of GMM, which allows us to control for autocorrelation and endogeneity simultaneously. We do not include financial institutions nor interaction effects of aid and financial institutions since cointegration implies that omitting these variables does not change the long-run relationship between TFP and aid (and the control variables). In addition, controlling for endogeneity and autocorrelation leads to consistent and efficient parameter estimates of the existing long-run relationship.

5.2 | The relative importance of TFP determinants

To assess which factors contribute most to TFP, we calculate the standardized beta coefficients for all determinants of TFP in Table 6. We use the beta coefficients from the regressions to the

TABLE 6 The relative importance of TFP determinants (based on coefficients from Table 3)

	Standardized betas TFP level (ln_TFP_index)
Net ODA	−0.039
Grants	−0.140*
Loans	−0.007
Bilateral aid	−0.117**
Multilateral aid	−0.035
Sector-related aid	+0.045
Trade openness	+0.165***
Inflation	−0.043
Government consumption	+0.014
Freedom	−0.020
Capital–labor ratio	+1.125***

***$p < .01$, **$p < .05$, and *$p < .1$.

Abbreviations: ODA, Official Development Assistance; TFP, total factor productivity.

mean (from Table 3) and use the averaged effects for the control variables. The significant determinants are in bold font.

Not surprisingly, the capital–labor ratio is the most important determinant of TFP, characterizing the level of technology present in developing countries and combining factors such as education and investment. In terms of relative importance, the capital–labor ratio is approximately 10 times more important for TFP than trade openness (having a positive influence) and grants and bilateral aid (having a negative influence). Furthermore, we see that the negative impact of grants and bilateral aid corresponds size-wise to the positive impact of trade openness on TFP (the same holds for TFP growth, see Table A7). Therefore, the impact of both types of aid is not negligible given that it is well known that trade openness puts pressure on the productivity of the export and import substitution industry. As such, we conclude that both grants and bilateral aid diminish TFP (at least from 1973 to 1999), and the effect is economically important or, more precisely, as important as trade openness.

6 | CONCLUSION

The aim of this paper was to perform an in-depth analysis of whether, and to what extent, aid influences productivity in developing countries and whether different types of aid impact productivity differently. We hypothesized that aid might have a negative impact on TFP by incentivizing activities that require less effort and are unproductive. As evidence of effort is difficult to observe with macroeconomic data, we leave it to microeconometric research to delve deeper into productivity-increasing or productivity-decreasing channels of development aid. We find empirical evidence for an overall negative and significant effect of aid on productivity, especially when it is given in the form of grants or bilateral aid disbursements. This negative impact of aid in the form of grants and bilateral aid cannot be observed after 2000. We relate this finding to a change in aid strategy. Starting in the early 2000s, the importance of ownership, accountability,

and responsibility in recipient countries was considered key in improving aid effectiveness and making the impact of aid measurable.

Considering these findings, we would not advise distributing aid in the form of grants (Lerrick & Meltzer, 2002; Radelet, 2005). Disbursing grants to less-developed, low-productivity countries might cause further harm to economic growth, as this form of aid weakens economic growth via the TFP channel.

In terms of policy conclusions, we recommend that aid agencies encourage greater participation by recipient countries in the decision-making process. Whenever possible, recipient countries should prioritize and co-finance development projects to generate more support for ongoing projects and prevent counterproductive disincentives caused by development aid in the form of grants. Bilateral aid should be more carefully distributed, as it harms productivity in recipient countries, while multilateral aid has a more neutral effect on a country's productivity. Whether bilateral aid has a negative impact in recipient countries because it stems from donors' strategic interests requires further research. Sector-related aid, according to the definition made in this paper, does not harm countries in low-productivity quantiles, whereas it seems to have negative effects on productivity in more productive developing countries. A quantile-specific policy needs to be implemented when sector-related aid is a factor. Overall, we advise supporting recipient countries' ownership and leadership in development projects, refraining from disbursing grants, and being more prudent with bilateral aid in all quantiles.

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DATA AVAILABILITY STATEMENT

The data used in this study are obtained from different sources. The data are available on request.

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ENDNOTES

[1] Compared to annual data, the disadvantage here is a loss of information. In addition, testing for autocorrelation becomes very unreliable with seven observations per country. In addition, using 5-year TFP growth rates as the dependent variable and nonstationary (I(1)) explanatory variables can lead to spurious regressions if 5-year TFP growth (based on annual growth rates) is stationary (I(0)); see Baffes (1997).

[2] In contrast, we use annual net ODA as a share of GDP.

[3] Rent-seeking behavior is measured by a constructed index out of corruption in government, rule of law, risk of repudiation of government contracts, risk of expropriation, and quality of bureaucracy from the International Country Risk Guide data set.

[4] Therefore, we pay tribute to the fact that changes in aid might take many years to impact on productivity, and therefore, short- to medium-run effects of aid on TFP are not to be expected. As all adjustments have come to an end in the long run, no adjustment lags appear in cointegration-based estimations.

[5] Bosworth uses 1960 but we use 1972 as base year as other data are available only later.

[6] We are aware that measurement error in the data has an impact on the computation of TFP. However, we consider its impact by applying the FGLS technique that can mitigate swings (also due to measurement error) in the error terms.

[7] In most developing countries, the informal sector is estimated to be very large as up to 60% of workers are employed in it (ILO, 2018). The size of the informal sector is closely related to productivity of humans and resource allocation (Loayza, 2016).

[8] In contrast, other data sets such as the Penn World Tables utilize three different purchasing power parities for investment, consumption, and government consumption. This causes expenditure shares to change dramatically after conversion, leading to rather inconsistent figures.

[9] Excluded variables are financial openness (FDI/GDP) and financial development (domestic credit to private sector/GDP); these are, however, highly correlated with trade openness.

[10] Data are available on request from the authors.

[11] $TFPgrowth = \ln TFP_{it} - \ln TFP_{i,base} = \ln(Y/L)_{it} - \ln(Y/L)_{i,base} - \alpha(\ln(K/L)_{it} \_ \ln(K/L)_{i,base}) - (1-\alpha)(\ln H_{it} - \ln H_{i,base})$, where $\alpha = 0.35$, Y/L is the output per worker; K/L is the capital–labor share, and H is the human capital measured by years of schooling.

[12] $Annual\_TFP\_growth = \ln TFP_{it} - \ln TFP_{it-1} = (\ln TFP_{it} - \ln TFP_{i,base}) - (\ln TFP_{it-1} - \ln TFP_{i,base})$.

[13] Endogeneity could also occur in the form of reverse causality.

[14] In the presence of cross-section correlation, a first-best estimation strategy is seemingly unrelated regression, which is feasible only if the number of cross-sections is small.

[15] See Tables A3 and A4 showing that these criteria are fulfilled.

[16] The coefficients $\chi_{k,p}$ are not necessarily consistent or economically meaningful, but they absorb the endogenous part of our variables of interest and render their coefficients (β_k) unbiased and consistent.

[17] Estimation of country-specific aid coefficients would be an alternative strategy to reflect heterogeneity (Eberhardt & Teal, 2011, 2013; Herzer & Morrissey, 2013). However, this strategy usually leads to a wide dispersion of results, which impedes the identification of common characteristics. Quantile regression constitutes an intermediate strategy between pooling all countries and estimating cross-section-specific coefficients.

[18] Between 0.86 and 0.94.

[19] $\hat{\rho}$ appears in Tables 3 and A4 in the bottom line and varies slightly across regressions. In the quantile regressions underlying columns 1–3, a $\hat{\rho}$ of 0.94 is used, whereas in the regression capturing the impact of TFP-related aid, $\hat{\rho} = 0.86$ is utilized.

[20] The share of grants in ODA is 85%, while loans constitute only 15%. The share of multilateral aid in total allocable aid has been quite stable at about 28% over the past decade so that the larger part is distributed bilaterally (OECD, 2013).

[21] The Alvi and Senbeta (2012) study found multilateral aid to have a negative effect on TFP growth.

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APPENDIX

TABLE A1 Data and sources

Variable	Definition	Source
TFP = A	$\Delta \ln A = \Delta ln \frac{Y}{L} - \alpha\left(\Delta ln \frac{K}{L}\right)(1-\alpha)(\Delta \ln H)$	Bosworth and Collins (2003) and Bosworth
Net ODA	Net ODA as % of GDP	OECD (2015)
Net ODA_grants	ODA grants as % of GDP	OECD (2015)
ODA_loans	ODA gross loans as % of GDP	OECD (2015)
Multilateral ODA	ODA multilateral aid as % of GDP	OECD (2015)
Bilateral ODA	ODA bilateral aid as % of GDP	OECD (2015)
TFP-related ODA	Aid related to TFP based on CRS codes	AidData
Trade openness	Trade (exports + imports) as share of GDP	WDI (2015)
Inflation	Rate of price change in the economy	WDI (2015)
Government consumption	Government consumption expenditure as % of GDP	WDI (2015)
Freedom House Index	Country classification according to 1 = free, 2 = partly free, and 3 = not free	Freedom House Org.
Capital–labor ratio	Ratio of physical capital per worker	Bosworth

Abbreviations: CRS, Creditor Reporting System; GDP, gross domestic product; ODA, Official Development Assistance; TFP, total factor productivity; WDI, World Development Indicators.

TABLE A2 List of countries

Algeria	Malaysia
Argentina	Mali
Bangladesh	Mauritius
Bolivia	Mexico
Brazil	Morocco
Cameroon	Mozambique
Colombia	Nicaragua
Costa Rica	Nigeria
Cote d'Ivoire	Pakistan
Cyprus	Panama
Dominican Republic	Paraguay
Ecuador	Peru
El Salvador	Philippines
Ethiopia	Rwanda
Ghana	Senegal
Guatemala	Singapore
Guyana	South Africa
Honduras	Tanzania
India	Thailand
Indonesia	Tunisia
Israel	Turkey
Jamaica	Uganda
Jordan	Uruguay
Kenya	Zambia
Madagascar	Zimbabwe
Malawi	

TABLE A3 Augmented Dickey Fuller panel unit root (ADF and Covariate Augmented Dickey-Fuller [CADF]) tests

Variable	Observations	ADF-Fisher $\chi 2$ statistic	Probability	CADF *Z*-statistic	Probability
ln_TFP_index	1,847	100.89	0.77	−0.416	0.34
TFP_growth_1972 (with respect to base 1972)	1,847	95.25	0.87	0.545	0.71
ln_SH_NET ODA	1,667	120.04	0.20	−1.30	0.10
ln_SH_GRANTS	1,622	114.13	0.32	−0.26	0.40
ln_SH_LOANS	1,697	95.11	0.81	−0.93	0.18
ln_SH_BAID	1,634	113.62	0.34	−1.62	0.05
ln_SH_MAID	1,435	106.93	0.51	−0.213	0.42
ln_SH_TFP_AID	777	101.82	0.43	na	na
ln_trade	1,757	119.12	0.22	−1.95	0.03
ln_inflation	1,357	91.41	0.72	NA	na
ln_GOVT_CONSUMPTION	1,514	99.40	0.71	−4.01	0.00
ln_FREEDOMHOUSE	1,437	107.68	0.10	2.807	0.99
ln_K-L_RATIO	1,568	132.92	0.09	0.61	0.34

Notes: H_0: series has a unit root (individual unit root process). H_a: at least one panel is stationary. Table A3 shows that all series have a unit root at a confidence level of 0.90 following the ADF test. Controlling for cross-section dependence and utilizing a CADF test the results are mainly in line with the ADF results but less clear-cut. A time trend and two or three lagged differences were utilized.

Also note that annual TFP growth (not listed here and not used in our regressions) is clearly stationary (I(0)), *p*-value being 0.00. *TFP_growth_1972*, in contrast, is nonstationary and cointegrated with the right-hand-side variables (see Table A4).

Abbreviations: na, not available; ODA, Official Development Assistance; TFP, total factor productivity.

TABLE A4 Kao residual cointegration test

Cointegration between the following set of variables	Included observations	ADF-*t*-statistic	Probability
ln_TFP_index regressed on *ln_SH_NET ODA* and controls	1,411	−1.78	0.04
ln_TFP_index regressed on *ln_SH_GRANTS*, *ln_SH_LOANS,* and controls	1,413	−2.55	0.01
ln_TFP_index regressed on *ln_SH_BAID*, *ln_SH_MAID,* and controls	1,323	−1.41	0.08
ln_TFP_index regressed on *ln_SH_TFP_AID* and controls	866	1.43	0.08
TFP_growth_1972 regressed on *ln_SH_NET ODA* and controls	1,411	−1.91	0.03
TFP_growth_1972 regressed on *ln_SH_GRANTS*, *ln_SH_LOANS,* and controls	1,413	−2.79	0.00
TFP_growth_1972 regressed on *ln_SH_BAID*, *ln_SH_MAID,* and controls	1,323	−1.60	0.05
TFP_growth_1972 regressed on *ln_SH_TFP_AID* and controls	866	1.64	0.05

Notes: H_0: no cointegration. Table A4 shows that the series are cointegrated and thus are in a long-run relationship. There is no cointegration between annual TFP growth (not listed here and not used in our regressions) as it is stationary and the right-hand-side variables are nonstationary.

Abbreviations: ODA, Official Development Assistance; TFP, total factor productivity.

TABLE A5 Tests on cross-section dependence of the residuals

Testing the residuals of the following regressions	Test	Statistic	Probability
ln_TFP_index regressed on *ln_SH_NET ODA* and controls	Pearson CD Normal	8.73	0.00
ln_TFP_index regressed on *ln_SH_GRANTS*, *ln_SH_LOANS,* and controls	Pearson CD Normal	9.12	0.00
ln_TFP_index regressed on *ln_SH_BAID*, *ln_SH_MAID,* and controls	Pearson CD Normal	6.07	0.00
ln_TFP_index regressed on *ln_SH_TFP_AID* and controls	Pearson CD Normal	8.80	0.00

Notes: H_0: cross-sectional independence of the error terms. Table A5 points to cross-sectional dependence that will be accounted for by the White cross-section method (Arellano, 1987; Wooldridge, 2002).

Abbreviations: ODA, Official Development Assistance; TFP, total factor productivity.

TABLE A6 The impact of aid on TFP growth—DFGLS estimation

	1 TFP_growth_1972	2 TFP_growth_1972	3 TFP_growth_1972	4 TFP_growth_1972
ln_net_ODA	−0.004			
	(0.004)			
ln_grants		−0.020**		
		(0.012)		
ln_loans		−0.001		
		(0.006)		
ln_multilateral ODA			−0.004	
			(0.006)	
ln_bilateral ODA			−0.017**	
			(0.008)	
ln_TFP-related ODA				0.005
				(0.005)
ln_trade openness	0.080***	0.076***	0.075***	0.010***
	(0.021)	(0.021)	(0.004)	(0.030)
ln_inflation	−0.011***	−0.009***	−0.007*	−0.009
	(0.003)	(0.003)	(0.004)	(0.006)
ln_government consumption (as % of GDP)	0.013	0.018	0.033	−0.006
	(0.018)	(0.017)	(0.021)	(0.028)
ln_freedom house index	−0.024	−0.014	−0.017	0.005
	(0.016)	(0.014)	(0.017)	(0.015)
ln_capital-labor_ratio	0.094**	0.085***	0.115***	0.151
	(0.043)	(0.046)	(0.043)	(0.067)
Constant	−0.180***	−0.160***	−0.135***	−0.098
	(0.140)	(0.135)	(0.140)	(0.209)
Observations	1,175	1,193	1,047	650
Endogeneity control (one lead and one lag)	Yes	Yes	Yes	Yes
Autocorrelation control (FGLS)	Yes	Yes	Yes	Yes
Country-fixed effect	Yes	Yes	Yes	Yes
Cross-sections	50	50	50	47
R^2	0.979	0.981	0.980	0.988
Durbin–Watson statistic	1.795	1.828	1.867	1.783
Autocorrelation coefficient (AR(1))	0.938	0.936	0.936	0.857

Notes: DFGLS estimation: control for autocorrelation via FGLS; control for endogeneity via DOLS; White cross-section standard errors are in parentheses; ***$p < .01$, **$p < .05$, and *$p < .1$. Comment: the results of Table A6 are in line with those of Table 3. It appears that the determinants of TFP_growth_1972 and the TFP level are very similar and so is their impact on TFP (growth).

Abbreviations: DFGLS, dynamic feasible generalized least squares; DOLS, dynamic ordinary generalized least squares; GDP, gross domestic product; ODA, Official Development Assistance; TFP, total factor productivity.

TABLE A7 The impact of aid on different quantiles of the distribution of TFP growth

	1	2	3	4	5		
	Q.10	**Q.25**	**Q.50**	**Q.75**	**Q.90**	**Observations**	**Pseudo R^2**
Ln _net_ODA	−0.024**	−0.023***	−0.019***	−0.016**	−0.013	1,175	0.105
	(0.013)	(0.008)	(0.008)	(0.008)	(0.009)		
ln_grants	−0.031	−0.031***	−0.033***	−0.029***	−0.040***	1,193	0.110
	(0.020)	(0.011)	(0.009)	(0.009)	(0.009)		
ln_loans	−0.005	0.000	0.004	0.004	0.005	1,193	0.110
	(0.006	(0.008)	(0.006)	(0.008)	(0.008)		
ln_multilateral ODA	−0.017	−0.004	0.006	0.010*	−0.003	1,047	0.114
	(0.010)	(0.006)	(0.005)	(0.005)	(0.009)		
ln_bilateral ODA	−0.057***	−0.038***	−0.038***	−0.036***	−0.026***	1,047	0.114
	(0.010)	(0.010)	(0.009)	(0.009)	(0.011)		
ln_sector-related ODA	−0.008	−0.005	−0.017**	−0.029***	−0.026***	650	0.100
	(0.008)	(0.006)	(0.008)	(0.007)	(0.008)		

Notes: Regressions are performed with the least absolute distance method. Endogeneity and autocorrelation are controlled for using an approach based on the DFGLS procedure. The coefficients of the control variables are not reported but available on request. Huber-Sandwich standard errors are used. Gray shade refers to statistically different slope coefficient across quantiles. Comment: the results of Table A7 are in line with those of Table 4. It appears that quantile regressions on TFP growth are in line with quantile regressions on the TFP level.

Abbreviations: DFGLS, dynamic feasible generalized least squares; ODA, Official Development Assistance; TFP, total factor productivity.

TABLE A8 The relative importance of the determinants of TFP growth

Standardized betas	TFP growth
Net ODA	−0.030
Grants	**−0.145**
Loans	−0.008
Bilateral aid	**−0.127**
Multilateral aid	−0.038
TFP-related aid	+0.049
Trade openness	**+0.180**
Inflation	−0.042
Government consumption	+0.016
Freedom	−0.022
Capital–labor ratio	**+1.124**

Notes: Significant coefficients appear in bold font. Comment: the results of Table A8 are in line with those results of Table 5. The relative importance of the capital–labor ratio is largest, followed by trade openness. Interestingly, grants and bilateral aid are of similar importance as trade openness but with opposite sign as hypothesized.

Abbreviations: ODA, Official Development Assistance; TFP, total factor productivity.