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What effect does development aid have on productivity in recipient countries?
An analysis using quantiles and thresholds

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

An analysis using quantiles and thresholds

by
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Abstract

Development aid does not always exert the desired positive effect on economic growth in recipient countries and it is even feared that it may reduce total factor productivity (TFP) and may discourage recipient countries' efforts. This study seeks to contribute to the research on aid transmission channels, in particular on macroeconomic channels such as private investment, domestic savings and the real exchange rate. By using panel data from 27 recipient countries over a 25-year period (1985-2009) this study aims to analyze the impact of the different forms of aid (grants, loans, bilateral and multilateral) on productivity, controlling for institutional factors and economic policy, using time-series panel techniques and focusing solely on the aid-productivity link. In order to examine possible vicious circles of aid, we run quantile regressions to ascertain whether aid is less effective in countries from the lowest TFP quantiles. To check for TFP-impeding conditions that are supposedly present in those quantiles, threshold regressions are performed to detect the ineffectiveness of aid below certain thresholds, including those of institutional quality, investment-to-GDP ratio, or domestic savings-to-GDP ratio. We find differences between the impact of aid in the form of grants and loans and the impact of bilateral and multilateral aid, with evidence that aid reduces TFP growth in the 0.1 and 0.25 quantiles. The search for sensible threshold values of aid impeding factors (institutional quality or key macroeconomic variables) was without result.

Keywords: TFP growth, foreign aid, quantile regression, smooth transition models

JEL Classification Codes: O4, O11, F35, C21, C22

1. Introduction

In recent years there has been intense academic debate on the effectiveness of development aid in general and its impact on economic growth in particular. Recent studies often failed to find evidence of a significant and positive effect of aid on aggregate economic growth per capita and tend to conclude that if there is an effect, it must be fairly limited (see Rajan and Subramanian, 2008; Arndt et al., 2009 for a comprehensive overview). Consequently, the question that arises is: Why does aid not boost economic growth and what are the channels through which aid has an impact on growth?

Previous studies find macroeconomic reasons for aid ineffectiveness, which include insufficient stimulus of investment in recipient countries, a crowding-out of domestic savings or an appreciation of the real exchange rate (Rajan and Subramanian, 2011). While development aid is found to have a very small, but positive and significant impact on investment (Doucouliagos and Paldam, 2006; Nowak-Lehmann et al., 2012; Alvi and Senbeta, 2012), this effect is counteracted by both an appreciation of the real exchange rate (Rajan and Subramanian, 2011; Nowak-Lehmann et al., 2012) and a crowding-out of domestic savings (Nowak-Lehmann et al., 2012). In addition, Alvi and Senbeta (2012) point to another negative effect of aid, namely a productivity-diminishing effect through adverse financial conditions. The existence of those negative effects of aid is reflected in the aid effectiveness literature, as the empirical findings on the aid-income link are rather mixed. Whereas in the more recent literature, Rajan and Subramanian (2008), Doucouliagos and Paldam (2009, 2010, 2013), Nowak-Lehmann et al. (2012) and Herzer et al. (2014) were unable to establish a positive and significant relationship between aid and per capita income, the research team around Tarp (Lof et al. 2013 and 2014) came to opposite conclusions using the same data set, a different (shorter) time period, a different aid indicator and different estimation techniques. In addition to macroeconomic problems associated with aid, bad institutions, bad governance (Bräutigam and Knack, 2004) and poor economic policy (Burnside and Dollar, 2000, 2004) might hinder the ability of aid to positively affect growth.[1] Some studies found aid to actually increase corruption (Ali and Isse, 2003; Djankov et al., 2008) by strengthening the predatory power of the government. The opposite, whereby aid reduces corruption, was found by Tavares (2003) and Okada and Samreth (2012). Selaya and Thiele

[1] The failure of aid to become effective has been examined by Easterly (2003) and Easterly et al. (2003). Easterly mainly points to the damaging effect of aid on economic incentives.

(2012) find evidence that the grant component of aid in particular impairs bureaucratic quality. Alvi and Senbeta (2012) find that aid distorts financial conditions and leads to the inefficient allocation of financial resources to less efficient projects.

In this study we further examine the economic impact of aid on growth by investigating the impact of aid on productivity. The objective of this study is to analyze how and to what extent development aid influences TFP growth in recipient countries over longer periods of time. To the best of our knowledge, with the exception of a study by Alvi and Senbeta (2012), the aid-productivity transmission channel is still under-researched; this despite the fact that TFP is an important source - if not *the* most important source - of economic growth (Caselli, 2005).[2]

Our main variable of interest, TFP, is the residual of growth accounting and measures the income growth per worker not attributable to factor accumulation, be it physical capital, labor or human capital. Thus, TFP measures a combination of change in efficiency in the use of factor inputs along with change in technology (Bosworth and Collins, 2003). The change in efficiency is reflected through a better quality of inputs, better functioning markets and better institutions.

The current study intends to shed light on the determinants of TFP and utilizes panel regression techniques to investigate the channel linking aid and TFP. The techniques employed control for endogeneity by taking the time series properties of the data set into consideration. Baseline regressions using Dynamic Feasible Generalized Least Squares (DFGLS) and Vector Autoregression Models (VAR) show that development aid does not have a significant impact on TFP, i.e. aid does not significantly influence the efficiency or technical change in recipient countries in the sample used. Cointegration analysis of the data series (which unit root tests confirm to be non-stationary) shows there are more than three cointegrating vectors in the full model with six or more explanatory variables. This is an indication of potential difficulties in establishing clear-cut relations, thus requiring a different level of analysis using more differentiated research questions:

First, does aid have a different impact in countries with lower productivity growth compared to countries with higher productivity growth? In particular, does aid affect the lower end of the distribution in a different way? Is it less or more effective there? To this end, we perform

[2] In economic growth models there are usually three main sources of economic growth: increase in capital per worker, increase in education (and other human capital) and total factor productivity (TFP) growth.

quantile regressions described by Delgado (2008), Marzban (2008), Kleiber (2010), Canay (2011) and Baum (2013).

Second, does aid become effective only after a certain threshold of productivity-enhancing variables has been surpassed? More precisely, might a certain level of investment, savings or institutional quality be necessary in order for aid to exploit its potential? Such an analysis requires threshold regression models or, more specifically, panel smooth transition models; threshold regressions, however, are computationally demanding. Explanations and examples of the methodology can be found in González et al. (2005) and in Jude and Levieuge (2013).

Our empirical results indicate that aid does not affect TFP growth over longer time spans, with aid in the form of grants even having a negative and significant impact on productivity growth. In addition, the impact of aid is negative and significant in the 0.1 and 0.25 quantile of the TFP growth distribution thus indicating a vicious circle in those quantiles. There is evidence that aid distributed via multilateral channels improves TFP performance. In contrast, an improvement in institutional quality and an increase in the capital-labor ratio seem to have a positive impact for all quantiles of the distribution of TFP growth. As to our results from the threshold/smooth transition regressions, most of the commonly accepted relevant thresholds seem to be non-binding so that further research needs to be done on how aid can be made more effective.

The paper is structured as follows: In Section 2 we briefly review the theoretical and empirical literature on the determinants of productivity. Section 3 contains the general empirical model used to quantify the impact of aid on productivity. Section 4 describes the data for the analysis. In Section 5 we present our general results. In Section 5.1 and in 5.2 we analyze the impact of aid in the lower quantiles of the TFP distribution to see whether aid has a different impact in countries with and at times of poor TFP performance. In Section 5.3 and 5.4 we perform further robustness checks in an attempt to uncover an indirect impact of aid, i.e. the combined impact of aid when aid interacts with factors such as institutional quality. Section 6 concludes.

2. Empirical literature on TFP growth

The theoretical literature on the drivers of sustainable growth of output and productivity is still shaped by seminal research of 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. Along the same lines, 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) focused on the importance of economic integration and specialization for economic growth and productivity. In a recent paper Stokey (2015) lists five strains of literature which point to the crucial role of technology in economic growth: developed country growth accounting exercises, cross country studies and development accounting exercises, empirical evidence of OECD countries, and late developer countries with periods of growth above 5% (growth miracles). The theoretical model developed in her paper explains stagnating or low growth rates to be the result of the interaction between technology inflow and human capital accumulation keeping countries in a stagnation steady stead with constant factor levels.

Easterly and Levine (2001), Caselli (2005) and Baier et al. (2006) provide empirical evidence that TFP is at least as important for growth as capital accumulation and thus argue that TFP growth should receive more attention. To date, empirical research has analyzed the role of R&D, human capital, trade openness, financial openness, foreign direct investment (FDI) and foreign ownership as drivers of productivity, mostly with respect to industrialized countries. Kose et al. (2009) turned their attention to the interplay of de facto and de jure financial openness and TFP. Keller and Yeaple (2003) focus on the contribution from trade and FDI on 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 transfer and TFP performance are supported by the presence of high-productivity foreign multinational companies which 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 information and communication technologies (ICT). Overall, most of the studies mentioned analyzed the determinants of TFP growth in developed countries; consequently there is a need to understand productivity growth in developing countries where R&D, ICT and financial markets are under-developed meaning that other determinants of TFP will drive changes.

Even less is known about the determinants of TFP and the role played by *development aid* with respect to TFP growth of recipient countries, although TFP is one of the fundamental transmission channels through which development aid is assumed to trigger economic growth

(Hansen and Tarp, 2001; Alvi and Senbeta, 2012; Jackson, 2014). Hansen and Tarp (2001) find little evidence that aid impacts growth directly but rather indirectly 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 TFP from an aggregate production function, using five-year averages and the system GMM estimation approach. They measure aid by official development assistance (ODA) as a share of GDP[3] using five-year averages of their set of variables, and also consider subcategories of ODA, such as multilateral and bilateral aid and grants and loans. The study finds that multilateral aid does indeed stimulate investment but that grants and multilateral aid have a dampening effect on TFP growth. Hence, the negative impact of aid on TFP reduces the overall positive effect of aid on growth. According to the authors, aid undermines the efficacy of financial institutions in supporting productivity growth. Jackson (2014) uses R&D and health expenditure as TFP proxies and finds no effect of aid on either these productivity measures or economic growth; aid seems to be used more for household consumption than for increasing investment.

We add to the previous literature by shifting the focus towards the role of development aid with respect to productivity growth. TFP is explained by a multiplicative model which reflects the fact that TFP is a product of non-additive and inseparable factors, such as aid, policy and institutions.

3. Data and Methods

Our measure of TFP has been computed by Bosworth (2013) and is measured as a residual in a growth accounting framework at an annual level (Bosworth and Collins, 2003). The whole data set contains measures on GDP growth, TFP growth, capital accumulation, growth of the labor force, and growth of human capital (years of schooling) for 84 countries in the 1960-2008 period. In Bosworth and Collins (2003) the growth rate of TFP was calculated using growth accounting assuming a production function with constant returns to scale. The main difference between this data set and other empirical growth data sets usually used is that estimates are based on constant national prices and not international prices as in the Penn World Tables (PWT). The construction of price measures of investment, consumption and government consumption using three different purchasing power parities (PPP) in the PWT causes expenditure shares to change dramatically after conversion. The data used by

[3] We use annual net ODA in real terms.

Bosworth and Collins (2003) uses a 'first-best' measure of the capital stock, based on national prices constructed by Nehru and Dhareshwar (1993).

As we are interested in how development aid influences productivity growth in aid recipient countries, the Bosworth data set used in this study is restricted to developing countries. We complement the TFP data with information on aid (OECD aid statistics, 2015), institutional quality (from the International Country Risk Guide ICRG), macroeconomic performance and economic policy conduct (World Development Indicators). The final sample contains a panel of 27 developing countries from Africa, Asia and Latin America for the 1985-2009 period.

We apply sophisticated econometric techniques that control for country heterogeneity and allow us to study lock-in effects of aid by relying on quantile regressions, as well as non-linearity of aid by applying a threshold/smooth transition model. We also control for the role of economic policy (openness, inflation, fiscal policy) and of institutional quality (government stability, bureaucratic quality, democratic accountability, law and order, corruption, ethnic tensions, religious tensions, external conflict, internal conflict) in all regressions. We have a reasonable number of control variables but one always remains open to the criticism of having failed to consider all possible variables that might affect productivity[4] (omitted variable bias). To tackle the omitted variable problem we apply the Feasible Generalized Least Squares technique (FGLS) correcting for a swing in the error terms caused by the compound of all omitted variables (Oberhofer and Kmenta, 1974). Furthermore, we address endogeneity bias by using the Dynamic Ordinary Least Squares (DOLS) technique to deal with endogeneity of all explanatory variables. Hence, to tackle the omitted variable problem and the endogeneity problem we apply a refined panel regression technique, namely Dynamic Feasible Least Squares (DFGLS), which combines the DOLS and the FGLS techniques. We also exploit some advantages of time series analysis (Vector Error Correction models - VECM) that allows us to differentiate between the short-run and the long-run influences of development aid on productivity.

In addition, our analysis seeks to uncover inherent aid traps or vicious circles of aid by analyzing whether aid affects productivity differently and negatively in low productivity growth countries (running panel quantile regressions) and by examining which productivity-enhancing thresholds of key macroeconomic factors have to be exceeded in order to make aid

[4] Left-out variables include financial openness (FDI/GDP) and financial development (domestic credit to private sector/GDP); these are, however, highly correlated to trade openness.

effective (panel smooth transition regressions). We also examine whether aid in interaction with other factors, such as good institutional quality, has a positive impact on productivity.

4. Explaining TFP growth: The empirical model

We use a broad definition of TFP growth that includes any productivity growth arising from increases in efficiency due to changes in the use of inputs of capital and human resources, changes in economic policy, development aid, institutional quality or technological progress, as shown in equation (1).

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

The subscript *i* stands for country and *t* depicts time. TFP is the level of total factor productivity. X_k are the *k* explanatory variables, i.e. the factors that enhance or impede productivity. We assume that the productivity drivers (*X*) impact productivity in a multiplicative way, with their impact being non-separable. The factors that are chosen to represent *X* and their expected impact on TFP are introduced in the following paragraphs.

Economic policy is considered an instrument that can increase efficiency in the short- or medium-run. In the related literature, economic policy is approximated by three subcomponents: openness, rate of inflation and government consumption as a percentage of GDP (Burnside and 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. It may, however, have a negative impact if it discourages market participation and dissuades producers of tradable goods from engaging in export production due to a lack of good infrastructure, no access to information and communication technologies and technological backwardness. *Inflation* (at least beyond a certain threshold) is thought to reduce efficiency as it is unclear to economic agents whether rising prices are caused by scarcities, good investment prospects or are a purely monetary phenomenon (excess money compared to output). Lower levels of inflation, in turn, 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 of private

activity and acts as a disincentive to efforts, it could also have a positive impact on productivity if the government takes over tasks in areas where there was no private investment and improves productivity of enterprises and households through linkage effects.

The role of net official development assistance (net ODA) for productivity has to date received little attention in the literature related to TFP growth. We expect ODA to have an indeterminate effect on productivity 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 reduce efficiency by crowding out domestic savings, leading to an overvalued real exchange rate thus damaging the production of tradable goods and distorting incentives.

Institutional quality is regarded as a long-term determinant of productivity as it influences multiple factors such as corruption, rule of law, and the general investment climate. We hypothesize that better institutional quality has a positive impact on productivity. In this study *institutional quality* is approximated by a composite index which is the unweighted average of *government stability, corruption, law and order, democratic accountability and bureaucratic quality.* The individual indices can take values from 0 to 10, with higher values representing better institutional quality.

As it is hard to get good and reliable data on R&D for developing countries we consider the *capital-labor ratio* as the 'second best' proxy for technological progress. By log-linearizing equation (1) and subtracting lagged log TFP from both sides we obtain equation (2) and equation (3), respectively. Since we expect path-dependency and thus the current rate of TFP growth to be determined by its past level, it is estimated by approximating $\ln TFP_{it-1}$ by $\ln(K/L)_{it-1}$:

$$\ln TFP_{it} - \ln TFP_{it-1} = \ln a_i + \sum_{k=1}^{K} b_k \ln X_{kit} - \ln TFP_{it-1} + u_{it} \qquad (2)$$

$$g_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \ln X_{kit} + \gamma \ln(K/L)_{it-1} + u_{it} \qquad (3)$$

Productivity growth *(g_{it}),* the dependent variable, is approximated by $lnTFP_{it}$ - $lnTFP_{it-1}$.

Equation (3) is then estimated by the Dynamic Ordinary Generalized Least Square (DOLS) approach (see equation (4)) including the set of explanatory variables discussed above. DOLS requires all series to be non-stationary and in a long-run equilibrium. DOLS allows us to control for the endogeneity of all right-hand-side variables by adding the variables in first differences and also the leads and lags of the first differences (Wooldridge, 2009). The coefficients $\chi_{k,p}$ and $\phi_{k,p}$ are not necessarily consistent nor economically meaningful but they absorb the endogenous part of our variables of interest and render their coefficients (β_k and δ) unbiased and consistent.

$$g_{it} = \alpha_i + \sum_{k=1}^{K} \beta_k \ln X_{kit} + \sum_{k,p=-1}^{K,p=+1} \chi_{k,p} \Delta \ln X_{kit-p} + \delta \ln(K/L)_{it-1} + \sum_{k,p=-1}^{K,p=+1} \phi_{k,p} \Delta \ln(K/L)_{kit-1-p} + v_{it} \quad (4)$$

As we detect autocorrelation, which is also an indicator of omitted variables, we apply the Feasible Generalized Least Square method to equation (4) yielding DFGLS. Heteroskedasticity is captured by computing robust standard errors.

5. Main results

The data set consists of 27 countries with annual data for the period 1985-2009. We examine three potential sources of vicious circles: first, the different impact of bilateral aid, multilateral aid, grants and loans[5]; second, whether aid has a different impact in countries and at times of low productivity growth; third, whether aid becomes effective when some TFP-enhancing control variables exceed a certain threshold or critical value.

5.1 Are there differences in impact between different types of aid?

As to our priors, aid in the form of grants could have a positive impact on productivity growth when recipient countries are intrinsically motivated to promote development and consider aid as a supplement to domestic savings. The disincentive effects of development aid have been pointed out by Easterly (2003) and Moyo (2009); it could have a negative impact when, as a result of receiving aid, governments reduce their efforts to finance expenditures through revenues, and/or when households and firms in recipient countries regard aid as an alternative to using their own savings as a source of investment finance. In contrast, we assume loans to

[5] The share of grants in ODA is 85% while loans make up only 15%. The share of multilateral aid in total allocable aid has been quite stable at around 28% over the last decade so that the larger part is distributed bilateral (OECD, 2013).

have a positive impact on productivity since investments made via loans are chosen more carefully due to the required interest payments and loan repayment.

When looking at long-run TFP growth using DFGLS, we find that aid - net official development aid as share of GDP (both grants and loans) - does not significantly influence productivity (Table 1a, col. 1). When breaking ODA down into 'grants' and 'loans' components (Table 1a, col. 2) we find that grants influence productivity negatively and significantly, controlling for endogeneity and autocorrelation. Loans, in contrast, have a positive but insignificant impact on productivity. Further research may reveal whether grants distort incentives and are carelessly used for unprofitable projects whereas loans are more carefully used because they require commitment to repayments. The fact that aid can be distributed via bilateral or multilateral channels does not seem to influence TFP growth in the long run (Table 1a, col.3 and col. 4). The control variables all have an insignificant influence on TFP growth when endogeneity and autocorrelation are accounted for. Reverse causality between openness, institutional quality, the capital-labor ratio and TFP growth therefore seems to be strong. Thus, when openness, institutional quality and the capital-labor ratio are exogenized, it leaves little that could spur TFP growth.

Table 1a The impact of aid (official development assistance) on TFP and GDP growth (DFGLS estimation)

	TFP Growth DFGLS (1)	TFP Growth DFGLS (2)	TFP Growth DFGLS (3)	TFP Growth DFGLS (4)
Openness	0.06	-0.12	0.06	0.05
	(1.06)	(-1.13)	(1.08)	(1.07)
Inflation	-0.001	-0.01	-0.001	-0.002
	(-0.11)	(-0.61)	(-0.34)	(-0.43)
Government consumption (as % of GDP)	0.04	-0.02	0.03	0.03
	(1.48)	(-0.19)	(1.58)	(1.50)
Net ODA	0.004	---	---	---
	(0.38)			
Net ODA_grants	---	-0.13***	---	---
		(-2.56)		
Net ODA_loans	---	0.03	---	---
		(1.17)		
Gross ODA	---	---	0.02	---
			(1.53)	
Bilateral ODA	---	---	---	0.01
				(1.13)
Multilateral ODA	---	---	---	0.01
				(0.66)
Institutional Quality (composite index)	0.04	-0.02	0.04	0.04
	(1.15)	(-0.32)	(1.18)	(1.10)
Capital-labor ratio	0.09	0.09	0.09	0.12
	(1.24)	(0.46)	(1.30)	(1.66)
Fixed effects	yes	yes	yes	yes
1 lead and 1 lag	yes	yes	yes	yes
Cross sections	25	16	25	25
Periods	20	18	20	20
Obs.	402	102	402	390
R-squared adj.	0.99	0.99	0.99	0.99
Durbin-Watson stat.	1.94	2.29	1.94	1.98

Note: All independent variables are in logs; the dependent variable is the growth rate which can be approximated by the difference of log TFP_t-log TFP_{t-1}; t-values in parentheses: White robust standard errors; Control for autocorrelation via FGLS; Control for endogeneity via DOLS

Next, we apply a VECM as an alternative estimation method which allows us to make statements on the short-run and the long-run impact of aid on TFP growth (Table 1b). The coefficients in Table 1b are long-run coefficients; we do not report the short-run coefficients although these are available on request. Equation (3), above, is written as a VECM containing an error-correction term in equation (5) and this will be used to compute the long-run coefficients and the variables in first differences that reflect the short-run behavior.

$$\Delta g_{it} = \kappa_i + \lambda ECT_{it-1} + \sum_{k=1,\, p=1}^{K,P=2} \pi_{k,p} \Delta \ln X_{kit-p} + \omega_{it} \qquad (5)$$

$$\Delta g_{it} = \kappa_i + \lambda (g_{it-1} - a_1 \ln X_{1it-1} - \ldots - a_k \ln X_{kit-1}) + \sum_{k=1,\, p=1}^{K,P=2} \pi_{k,p} \Delta \ln X_{kit-p} + \omega_{it} \quad (6)$$

Our main variable of interest, aid, does not have a significant short-run impact on productivity. Also the coefficients for the different components of aid, grants and loans, remain insignificant. Only when distinguishing between bilateral and multilateral aid do we find that aid distributed via multilateral channels seems to significantly increase long-run TFP growth.

With the exception of openness and inflation, all controls have an insignificant impact on TFP growth. Openness seems to increase TFP growth, as international trade can foster specialization and productivity. Inflation negatively impacts TFP growth since instable or volatile prices can cause uncertainty in investment projects.

Although we acknowledge that we would need more data to back up our estimations, these findings allow us to make two statements: Aid seems to have no impact on long-run TFP growth in general, though there is evidence that aid in the form of grants reduces growth (see DFGLS estimation), whereas aid allocated by multilateral donor agencies boosts TFP growth (see VECM estimation).

Table 1b The impact of aid (official development assistance) on TFP and GDP growth (VECM estimation)

	TFP growth VECM (1)	TFP growth VECM (2)	TFP growth VECM (3)	TFP growth VECM (4)
Openness	0.42***	0.45**	0.36	0.43**
	(2.39)	(1.91)	(2.19)	(2.23)
Inflation	-0.12***	-0.10***	-0.10	-0.11***
	(-4.74)	(-2.76)	(-4.31)	(-3.98)
Government consumption (as % of GDP)	-0.08	0.10	-0.06	-0.06
	(-1.01)	(0.87)	(-0.81)	(-0.81)
Net ODA	0.08	---	---	---
	(1.46)			
Net ODA_grants	---	0.00	---	---
		(0.05)		
Net ODA_loans	---	0.05	---	---
		(0.87)		
Gross ODA	---	---	0.08	---
			(1.55)	
Bilateral ODA	---	---	---	0.00
				(0.002)
Multilateral ODA	---	---	---	0.07**
				(1.64)
Institutional Quality (composite index)	-0.09	0.12	-0.19	-0.10
	(-0.94)	(0.89)	(-0.78)	(-0.98)
Capital-labor ratio	-0.24	-0.72**	-0.06	-0.25
	(-1.38)	(-2.32)	(-1.18)	(-1.32)
Fixed effects	yes	yes	yes	yes
Short-run aid	insignificant	insignificant	insignificant	insignificant
Cross sections	26	23	26	26
Periods	21	20	20	20
Obs.	452	181	435	424
R-squared adj.	0.25	0.46	0.23	0.23
Durbin-Watson stat.	2.08	2.20	2.16	2.17

Note: All independent variables are in logs; the dependent variable is the growth rate, which can be approximated by the difference of log TFP_t-logTFP_{t-1}; t-values in parentheses: White robust standard errors; we depict the long-run coefficients: The short-run coefficients of the aid variables are always insignificant.

5.2 Does aid have a different impact in countries with lower productivity growth, i.e. at the lower end of the quantile distribution of TFP growth?

As it is likely that lower productivity countries react differently to net aid inflows (be it grants or loans), we will test this hypothesis. We consider countries with lower productivity growth as countries which either lie in the 0.1 or 0.25 quantile of the TFP growth distribution. Since the quantile regressions were originally developed for cross-sectional studies with a common intercept, we have to adjust the quantile regression approach to use with panel data and allow for country fixed effects, which is not possible in the standard quantile regression setup. We follow Canay (2011), who introduced a simple transformation of the dependent variable to consider time-invariant country characteristics, assuming that these effects are intercept shifters. Canay (2011) proposes a two-step approach that consists of estimating country fixed effects (FE) using a within FE model in a first step. In a second step, the consistently estimated FE are used to demean the dependent variable (productivity growth) and this transformed variable is taken as a dependent variable in the quantile regression. The model estimated in the first step is given by equation (4) above. The estimated α_i are then used to transform *g* into:

$$\tilde{g}_{it} = g_{it} - \hat{\alpha}_i \qquad (7)$$

The quantile regression is estimated as,

$$\hat{\beta}(\tau) = \arg\min_{\beta \in \Theta} (nT)^{-1} \sum_{T=1}^{T} \sum_{i=1}^{n} \rho_\tau (\tilde{g}_{it} - X'_{it}\beta) \qquad (8)$$

Table 2 The impact of aid on different quantiles of the TFP distribution

	(1) M1(Q.1)	(2) M2(Q.25)	(3) M3(Q.5)	(4) M4(Q.75)
Capital labor ratio (t-1)	0.08***	0.08***	0.09***	0.08***
	(8.90)	(14.85)	(22.03)	(19.10)
Openness	0.03	0.07**	0.05**	0.05
	(0.39)	(2.24)	(2.14)	(1.59)
Inflation	-0.01	-0.01	0.01	0.01
	(-1.08)	(-076)	(1.18)	(1.54)
Government Consumption (as% of GDP)	-0.01	-0.02	0.00	0.04*
	(-0.11)	(-0.66)	(0.013)	(1.77)
Net ODA	-0.001***	-0.001**	-0.000	-0.000
	(-3.06)	(-2.28)	(-1.12)	(-0.50)
Institutional Quality (Composite Index)	0.03**	0.01*	0.01**	0.01*
	(2.35)	(1.91)	(2.01)	(1.73)
Endogeneity control (leads and lags of 1st differences[6])	Vars in 1st diff added	Vars in 1st diff added	Vars in 1st diff added	Vars in 1st diff added
Autocorrelation control	FGLS	FGLS	FGLS	FGLS
Obs.	417	417	417	417
Pseudo R2	0.34	0.34	0.34	0.34

Note: The dependent variable has been transformed: it has been demeaned by the country fixed effects to control for country heterogeneity; all variables have been transformed via the FGLS-method to correct for autocorrelation of the error terms

Table 2 shows that development aid has a significant and negative impact in the lower quantiles of the TFP distribution, implying that there are disincentive effects at work for countries with very low productivity levels. However, despite the statistically significant impact of aid, the effect is very small in economic terms. ODA does not have a harmful effect in countries with median or higher productivity growth. The capital-labor ratio is relevant, positive and significant for productivity growth for all quantiles and proves path-dependency. The composite index of institutional quality is always positive and significant and shows that improvements in institutional quality are good for productivity growth in all quantiles but has the most pronounced effect at the lowest end of the TFP distribution. Openness has a positive and significant value for the 0.25 and 0.5 quantiles, but no importance at the lowest 0.1 quantile and the 0.75 quantile. The impact of inflation and government consumption is not robust and mostly insignificant.

[6] Due to data limitations only the first differences of the right-hand-side variables were included. When the lags of the first differences were included as well they were not significant. When also including both the lags and leads of the 1st-differences, the t-statistics of all variables become incalculable.

Table 3 The impact of grants and loans on different quantiles of the distribution

	(1) M1(Q.1)	(2) M2(Q.25)	(3) M3(Q.5)	(4) M4(Q.75)
Capital labor ratio	0.07***	0.09***	0.10***	0.10***
	(4.15)	(8.61)	(14.95)	(11.78)
Openness	0.05	0.07*	0.06	0.04
	(0.37)	(1.86)	(1.48)	(0.79)
Inflation	-0.05	-0.004	-0.004	0.01
	(-1.20)	(-0.28)	(-0.39)	(0.37)
Government Consumption (as% of GDP)	-0.04	-0.07	-0.08*	-0.04
	(0.25)	(-1.40)	(-1.6801)	(-0.75)
Net ODA_grants	-0.05	0.00	-0.002	0.02
	(-0.67)	(0.06)	(-0.07)	(0.59)
Net ODA_loans	0.02	0.01	0.01	0.00
	(1.259	(0.30)	(1.18)	(0.15)
Institutional Quality (Composite Index)	-0.01	-0.00	0.01	0.01
	(-0.51)	(-0.45)	(1.06)	(150)
Endogeneity control (leads and lags of 1st differences[7])	Vars in 1st diff added	Vars in 1st diff added	Vars in 1st diff added	Vars in 1st diff added
Autocorrelation control	FGLS	FGLS	FGLS	FGLS
Obs.	110	110	110	110
Pseudo R2	0.47	0.47	0.47	0.47

Note: The dependent variable has been transformed: it has been demeaned by the country fixed effects to control for country heterogeneity; all variables have been transformed via the FGLS-method to correct for autocorrelation of the error terms.

Differentiating ODA in terms of its component grants and loans in Table 3 shows that the impact is insignificant in all quantiles of the productivity distribution i.e. it does not seem to influence productivity growth. The impact of loans is always positive but insignificant, whereas grants show a mixed picture but coefficients remain insignificant with no impact on TFP growth. The capital-labor ratio has a positive and significant impact in all quantiles of the distribution, increasing in the higher quantiles and pointing to the importance of capital-intensive production for productivity growth. The impact of openness, inflation, government consumption and institutional quality is mostly insignificant, not allowing any policy conclusions to be drawn.

[7] Due to data limitations only the first differences of the right-hand-side variables were included. When the lags of the first differences were included as well they were not significant. When also including both the lags and leads of the 1st-differences, the t-statistics of all variables become incalculable.

When we distinguish between bilateral and multilateral aid (results are available from the authors on request) the coefficients remained basically unchanged and insignificant, with the lagged capital-labor ratio (our measure of technology) being significant at the 10% level. Bilateral aid had a negative and significant impact in the 0.1, 0.25 and 0.5 quantiles, whereas multilateral aid had a negative but insignificant impact in those quantiles. It should be noted that the number of observations drops significantly (from 417 to 110) when differentiating between grants and loans, and we are therefore more confident reporting the results of the forms of aid combined in one variable as net ODA.

5.3 Does the impact of aid depend on other variables and certain threshold values? Can we break the vicious circle?

Thus far, we have not found a robust significant direct impact of aid on productivity, but it might still be the case that the impact of aid on TFP works in conjunction with other variables. Hence, we will first test for interaction effects, i.e. aid interacted with key macroeconomic variables and aid interacted with institutional variables. In a second step, we determine certain threshold values above which aid might have an impact on productivity.

According to the literature (Hansen, 2000; González et al., 2005), the relevance of interaction effects is tested by interacting aid with the so-called transition variables/threshold variables 'q' and its second and third moments.

We test for the relevance of the investment-to-GDP ratio, the savings-to-GDP ratio and variables such as external conflict, internal conflict, ethnic tensions, government stability, bureaucratic quality, democratic accountability, corruption, law and order, and a composite index of institutional quality, considering them as factors that could enhance the effectiveness of development aid. Significance of the interaction terms is seen as prerequisite for qualifying as a transition variable/threshold variable. According to Table 4, with the exception of the composite index of institutional quality and the index 'religious tensions', these variables fail to explain the impact of aid on productivity.

Testing for relevant transition variables/threshold variables

Table 4 Testing for transition variables

	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth	TFP growth
Transition variable (q)	*Investment/ GDP*	*Saving/GD P*	*External conflict*	*Internal conflict*	*Ethnic tensions*	*Governm ent stability*	*Bureaucr atic quality*	*Democra tic accounta bility*	*Corrupti on*	*Law & order*	*Institutional quality (composite index)*	*Religious tensions*
Net ODA	-0.01 (-2.38)	-0.01 (-1.37)	0 (-0.38)	0 (-0.30)	0 -0.11	0 (-0.17)	0 (-0.57)	0 (-0.80)	0 (-0.07)	0 (-0.13)	0 (-0.61)	0 (-0.03)
Net ODA x q	0 -4.8	0 -0.84	0.01 -1.06	0 (-0.01)	0 (-0.38)	0 -0.04	0 (-0.03)	0 (-1.11)	0 -0.57	0 (-0.79)	0 -3.09	0 -1.49
Net ODA x q^2	0 -1.15	0 (-0.31)	-0.01 (-1.36)	0 -0.17	0 -0.57	0 (-0.22)	0 -0.11	0 -1.18	0 -1.17	0 -1.06	0 (-2.90)	0 (-1.99)
Net ODA x q^3	0 (-1.06)	0 -1.13	0 -1.52	0 (-0.20)	0 (-0.60)	0 -0.47	0 (-0.15)	0 (-0.79)	0 (-1.07)	0 (-0.59)	0 -2.53	0 -2.18
Relevant interaction?	***no***	***no***	***no***	***no***	***no***	***no***	***no***	***no***	***no***	***no***	***inconclusive***	***inconclusive***
R^2	0.99	0.99	0.98	0.98	0.99	0.98	0.99	0.99	0.98	0.98	0.98	0.98
Durbin-Watson	1.88	1.83	1.78	1.8	1.8	1.8	1.92	1.88	1.8	1.82	1.8	1.8

Note: All variables are in logs; tests have been performed including country fixed effects, controlling for autocorrelation and computing robust standard errors; q = transition variable; t-values in brackets.

Applying a smooth transition model or threshold model

The above tests on the relevance of simple and higher order interaction terms have demonstrated that only institutional quality (composite index) and religious tensions can potentially qualify as threshold variables.

Hence, *we will apply a smooth transition model to these two variables*, studying their continuous impact and looking for a threshold value above which aid might be effective. By utilizing smooth transition models, we allow for heterogeneity in the regression coefficients that can vary both across countries and over time. The relevant coefficients are defined as continuous functions (transition functions) of an observable variable (transition variable/threshold variable) and fluctuate between limited numbers of regimes (in our case two regimes). As the transition variable q_{it} is country-specific and time-varying, the regression coefficients for each of the countries in the panel change over time.

Following González et al. (2005), who apply the smooth transition model to panel data (PSTR), we can formulate the following equation assuming *j* extreme regimes.

$$g_{it} = \mu_i + \beta_0^{'} x_{it} + \beta_1^{'} x_{it} trf(q_{it}; \lambda; c) + u_{it} \qquad (9)$$

Using a logistic specification for the transition function

$$trf(q_{it}; \gamma; c) = \left(1 + \exp(-\gamma \prod_{j=1}^{J} (q_{it} - c_j) \right)^{-1} \qquad (10)$$

with $\gamma > 0$ and $c_1 \leq c_2 \leq ..... \leq c_J$.

With only two regimes (j=1. i.e transition variable q_{it} is either below or above threshold value c) equation (9) turns into

$$g_{it} = \mu_i + \beta_0^{'} x_{it} + \beta_1^{'} x_{it} \left(1 + \exp(-\gamma(q_{it} - c)\right)^{-1} + u_{it} \qquad (11)$$

which is estimated via Limited Information Maximum Likelihood (LIML) on the demeaned variables to account for country fixed effects and to simulate a within LIML estimation.

β_0' is the impact of aid *that is independent from other variables (possible transition variables)*; β_1' is the impact of aid when the relevant transition variable q_{it} exceeds a certain threshold value *c*, i.e. when the transition variable moves from below *c* to above *c* and hence, aid moves from one regime to the other.

Table 5 illustrates that the pure impact of aid is insignificant, evidence which reinforces the results obtained earlier. The combined impact of aid[8] is also insignificant. This insignificant impact implies that neither institutional quality nor its subcomponent, religious tensions, add anything to the impact of aid. There are two reasons for this: first, we observe that the slope of the transition function is very flat, meaning that the transition variable does not really trigger any additional impact of aid nor is it generated by improving the institutional quality; and second, we note that the threshold value of the transition variable is extremely low (about 1). Remember that the transition variable can take values ranging from 0 to 10; the average value for institutional quality is about 3.4 and the average value for religious tensions is about 4.1, with higher values indicating better quality/less religious tension. The threshold value computed, then, suggests that virtually all countries in the sample reach or exceed this low value. Given, therefore, that this performance surpasses the threshold, institutional quality would seem not to play a role in stimulating growth via TFP.

Table 5 The impact of aid when a certain threshold value is exceeded

	Dependent variable: TFP growth LIML estimation, within transformation of variables	
Transition variable	**(1)** **Institutional quality**	**(2)** **Religious tensions**
Impact of aid (β_0)	0.002 (0.99)	0.000 (0.00)
Additional impact of aid (β_1) = coefficient of composite term	-0.002 (-0.00)	-0.001 (-0.00)
Slope of transition function	0.004 (0.00)	0.0001 (0.00)
Threshold value	-0.004 (0.00)	-0.001 (0.00)
Threshold value transformed	0.996	0.999
S.E. of regression	0.30	0.37
S.D. dependent var	0.29	0.29
Mean dependent var	0.02	0.02

Note: All variables are demeaned to account for country heterogeneity. Endogenous variables are instrumented. T-values in brackets.

[8] Here we assume that aid works better when the institutional quality is higher or when religious tensions are lower,

Robustness checks for the threshold model, differentiating between aid in the form of grants and loans, compared to bilateral and multilateral aid, are available from the authors and can be summarized as follows: as before, the threshold regressions did not reveal meaningful threshold values. The computed threshold values were very low and well below the average values of institutional quality and religious tensions. However, it seems that the means by which aid could potentially make a positive contribution to TFP growth would be through improving institutional quality rather than through alleviating religious tensions.

5. Conclusions

The objective of this paper was to perform a more in-depth analysis of whether and to what extent aid influences productivity in developing countries. Our prior was that aid might have a negative impact on TFP growth by incentivizing less productive activities. We find weak empirical evidence for an overall negative and significant effect of aid on productivity growth. In general, the impact of aid was insignificant and it remained insignificant even when institutional quality improved or exceeded the critical threshold value. However, we found a significant negative impact of aid when it was given in form of grants or when it was given to countries with very poor productivity growth performance. When aid is distributed via multilateral channels we found that it boosted TFP growth. However, the impact is, economically speaking, very small.

In light of the findings presented here, we would not advise distributing aid in the form of grants (Radelet, 2005; Lerrick and Meltzer, 2002). Giving out grants to very poor, low productivity countries might cause further harm to economic growth as they weaken economic growth via TFP. In terms of policy conclusions, therefore, we recommend that aid agencies work to encourage greater participation on the part of recipient countries when making decisions about aid projects. Recipient countries should be actively involved in identifying the target areas and target groups of development aid in order to improve buy-in to the aid projects. Whenever possible, recipient countries should be asked to co-finance development projects as a means of generating more support for the ongoing projects and preventing the counterproductive disincentives caused by development aid in the form of grants.

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