Thresholds in Aid Effectiveness

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Abstract: Is the big push hypothesis consistent with capacity constraints in the study of aid effectiveness? Big push hypothesis suggests the existence of a minimum threshold below which aid is not effective, while the constraints referred to by the concept of absorptive capacity suggests the existence of another threshold above which aid is no longer effective. This paper addresses the issue of multiple thresholds characterizing the aid/growth relationship. Using a semiparametric econometric method we do find that aid become effective only above a critical level but also become detrimental to growth for higher value of aid flows. We also investigate how the quality of economic policies and vulnerability modifies the level of those two thresholds. We finally propose a dynamic explanation of the aid/growth relationship.

JEL: F35, C14, O40

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1 - Introduction

Since the seminal work of Burnside and Dollar [2000], the question of the conditions on which aid effectiveness depends has become central in the aid debates. Basically, these two authors found that aid is effective only if the quality of the recipient country economic policy is good enough. Consequently in order to maximize aid efficiency, donors have to condition their disbursements on country policy and institutions ratings Collier and Dollar [2002]. This recommendation is still today widely carried out within the World Bank as well as in some national aid agencies, although serious doubts have been cast by many authors on the robustness and relevance of its grounds (see Roodman [2007] and Easterly et al. [2004] for recent formulations of the criticism). Besides country policies or institutions (or instead of them), Guillaumont and Chauvet [2001], Chauvet and Guillaumont [2004,2007] and Collier and Dehn [2001] put forth that macroeconomic vulnerability stemming from terms of trade or climatic shocks were to be accounted for to disentangle the effect of aid on growth, vulnerability being likely to increase the marginal impact of aid on growth.

Not independently from this first stream of thought, a second line of research argues that an important part of the story is ignored by not taking into account that the aid/growth relationship might display diminishing returns. Arguments in favor of such a hypothesis are numerous. Thus, Hadjmichael et al. [1995] referred to absorptive capacity constraints, Dubarry et al. [1998] discussed Dutch disease problems and capacity constraints and Lensik and White [2001] consider inappropriate technology and institutional destruction caused by the aid inflow as an explanation for what they called an “aid Laffer curve”. Heller and Gupta [2002] review the empirical evidence that very large aid flows can induce overwhelmed management capacity, undermine alternative revenue collection, and provide greater opportunities for corruption, among other impediments to growth. In those studies, as well as in Dalgaard and Hansen [2000] and Hansen and Tarp [2000, 2001], by introducing an "aid-squared" term in the regression, results displayed a strong, unconditional non-linear impact of aid on growth. Collier and Dollar [2001, 2002], combining diminishing returns and conditional effects of aid introduce the aid squared term besides the multiplicative "aid x policy" variable, what was needed to solve the problem of an optimal aid allocation. Gomanee et al. [2003] offer a different perspective: by implementing a threshold regression, they find no evidence of diminishing returns but do find a non linear impact of aid. They argue that aid stimulates growth positively and significantly only if the ODA to GNP ratio is above 2%. The evidences they put forth come in support for the big push thesis, whereas most of the literature focused on non-linearities in aid-growth relationships refers to capacity constraints.

Examining how to reconcile big push and absorptive capacity, Guillaumont and Guillaumont Jeanneney [2006a] suggest the existence of two successive turning points, a lower one corresponding to the aid level required for the big push, the upper one corresponding to absorptive capacity. But they consider that that these two points cannot be properly estimated simply by introducing squared and cubic aid terms (how to interpret the negative marginal returns below the lower threshold?) and that it would make difficult to treat simultaneously the possibly conditional effects of aid.

In this paper we argue that the assumption of two turning points is consistent and that multiple thresholds might characterize the aid/growth relationship as countries overcome or encounter new constraints. Our objective here is to readdress the non-linearity issue by implementing an econometric strategy allowing us to uncover the way growth respond to aid in a more complex but yet more understandable manner than the studies mentioned above. The semi-parametric model that we use is a partially linear model that allows for the non-linear component to enter additively. Whereas the traditional semi-parametric partially linear regression formulation treats the variables that enter the non-linear part of the model as nuisance variables, the semiparametric additive model allows for explicit estimation of the marginal effects of the non-linear components on the dependant variable. Furthermore, such estimation procedure offers graphical representations that provide a useful way of analyzing the data.

In the next section we present the basic econometric framework that we use to analyze our data. We then proceed to discuss our empirical findings. Finally, we conclude.

2 – **Methodological issues**

The core hypothesis of the literature that study nonlinear effects of aid on growth is that aid displays diminishing returns and above a certain threshold become detrimental to growth for particularly high aid to GNP ratio. Hence, some countries that receive aid flows above a particular ceiling should see their aid reduced to avoid those detrimental effects, as argued in Lensink and White [2001]. However, as shown in Gomanee and al. [2003], if there is a threshold where the aid/growth relationship reverse, the simple inclusion of a squared term might not be efficient to identify those turning points. Nevertheless, the threshold regression suffers from its own caveats. As the estimation process is sequential, the initial threshold values are never revised has the number of splits is rising. Hence, small change in the data might have a significant impact on the stability of the model.

Our objective here is to propose an empirical strategy that might address these several issues in a common framework. Nonparametric regression relaxes the usual assumption of linearity and enables the researcher to explore the data more flexibly, uncovering structure in the data that might otherwise be missed.

Hastie and Tibshirani [1986, 1990] proposed additive models. These models estimate an additive approximation to the multivariate regression function. The benefits of an additive approximation are at least twofold. First, since each of the individual additive terms is estimated using a univariate smoother, the "curse of dimensionality", Bellman [1961], is avoided, at the cost of not being able to approximate universally. Second, estimates of the individual terms explain how the dependent variable changes with the corresponding independent variables. Such methods usually combine features of parametric and nonparametric techniques. As a consequence, they are usually referred to as semiparametric methods. Further advantage of semiparametric method is the possible inclusion of categorical as well as continuous variables, which can be included in a parametric way. Additive semiparametric models are also interesting from a statistical point of view. They allow for a componentwise analysis and combine flexible nonparametric modeling of multidimensional inputs with a statistical precision that is typical of a one-dimensional explanatory variable.

A generalized linear model (GLM) is a regression model of the form

$$E(Y \mid X) = G(X'\beta),$$

Where Y is the dependent variable, here the rate of growth of GDP per capita, X is a vector of explanatory variables, with the aid to GDP ratio our variable of interest and the main other control variables used in the aid literature, β an unknown parameter vector and G(.) a known link function. The generalized additive partial linear model (GAPLM) extends the GLM by a nonparametric component and takes the form

$$E(Y \mid X, Aid) = G\{X'\beta + f(Aid)\},$$

where $E(Y \mid X, Aid)$ denotes the expected value of the dependent variable Y given X and Aid, the variable for which we want to explore non-linearities, here, the aid to GDP ratio. The index $X'\beta + f(Aid)$ is linked to the dependent variable Y via a known link function G(.). The parameter vector β and the function $f(Aid)$ need to be estimated. The flexibility and convenience of using a GLM formulation comes at the cost of two theoretical problems. It is necessary to determine how to smooth this component and also to determine how smooth it has to be. We then rely on regression splines for our previous to become linear. We have to choose a basis, defining the space of functions on which f is an element. Choosing a basis amounts to choosing some basis functions, which will be treated as completely known: if $t_j(Aid)$ is the j^{th} such basis function, then f is assumed to have a representation

$$f(Aid) = \sum_{j=1}^{q} t_j(Aid)\theta_j ,$$

for some values of the unknown parameters, θ_j. Combining those two equations clearly yields to a linear model. The second issue is about the level of smooth. If the objective is only to minimize the sum of squared residual, such method will yields to an estimation of f not smoothed enough to detected clear breaks. It is then necessary to set a penalty to the least squared objective for our estimation to become the best trade off between smoothing and fitting the data. Rather than fitting the model by minimizing,

$$\left\| Y - X'\beta - f(Aid) \right\|^2 ,$$

it could be fitted by minimizing,

$$\left\| Y - X'\beta - f(Aid) \right\|^2 + \lambda \int \left[f''(Aid) \right]^2 dA ,$$

where the integrated square of second derivative penalizes models that are not smoothed enough. The trade off between model fit and model smoothness is controlled by the smoothing parameter, λ. $\lambda \to \infty$ leads to a straight line estimate for f, while $\lambda = 0$ results in an un-penalized regression spline estimate. In this study, this penalty parameter will be estimated by generalized cross validation while other parameters are estimated using iteratively reweighted least squares (P-IRLS).

This methodology will allow us to estimate the non-linear component of the aid/growth relationship. The advantage of using this methodology is that we are not making any assumptions regarding the nature of the marginal returns (by including a aid-squared or cubic term) and the number of thresholds, providing us with a straightforward graphical representation of the GDP growth response on the whole range of the aid to GDP ratio. It also enables us to explore more efficiently some aspects of aid the conditional to other variables, as it is also possible to specify a function of multiple variables.

3 – Data presentation

The empirical analysis is based on data for 61 countries from the Roodman [2007] database. We use pooled cross-country data averaged over 8 four-years-periods from 1970 to 2001. Table 1 presents the list of countries included in the sample. We estimated a classical Barro-type growth equation with the 4 years average growth rate, GDPG as our regressand. In order to make our result more comparable with the current literature, we first choose to stay as close as possible to the Hansen and Tarp's [2001] main specification, although we use an extended sample. They include the initial level of GDP per capita, LGDP; an indicator of institutional quality from the international country guide, ICRGE; the natural logarithm of 1+consumer price inflation rate, INFL; the budget surplus, BB; the four year average of the Sachs and

Warner [1995] openness dummy variable updated by Wacziarg and Welch [2002], SACW; the state of the financial system proxied by M2 relative to GDP lagged of one period, M21; the ethnolinguistic fractionalization used by Easterly and Levine [1997], ETHN; the assassination variable to capture civil unrest, ASSAS; and the product of the last two, ETHNASSAS. We also include a regional dummy for each of the 4 region in the sample: Sub-saharan Africa, Central America, East Asia and Mediterranean countries, as well as a period dummy for each of our 8 period. This set of exogenous variables is composing the parametric part of our semiparametric specification.

As for our variable of interest, we use the Net Overseas Development Assistance to real GDP ratio provided by the World Bank, AID; in the nonparametric part of our estimation. Our sample mean value equals the one of Burnside and Dollar but it is still interesting to investigate on the distribution of this variable. The most striking figure in this respect is that 75% of our observations correspond to aid to GDP level below 2%.

Even if the estimation strategy is substantially different from the rest of the literature, the well-known endogeneity issue still troublesome. As shown by Sperlich [2005], it is possible to obtain consistent estimates by using instrumental variables in a two step procedure that is close the classical 2SLS estimator. This approach only requires a non, semi or even parametric construction of regressors of interest in the first step. In order to stay as close as possible of the current state of the art, we again chose to use the instruments proposed by Burnside and Dollar [2000] and Hansen and Tarp [2001] [1]. This set of instruments includes the lagged arms imports to total imports ratio, ARMS1; dummies for specific donors interests in the Franc zone in Africa, FRZ; in Central America, CENTAM; and in Egypt; EGYPT; lagged values for the aid, AIDL1 and policy, POL1 variables; an interaction term between policy and population variables, POLPOP; products of current and lagged values for aid, AIDL12 and policy, POL2 variables and interaction terms between policy and AIDL1, POLAIDL1 and AIDL12, POLAIDL12. The AID variable we use from now is the fitted value obtained, in a first step, by regressing parametrically our original Net ODA / GDP variable on all the variables mentioned above.

The last estimation issue concerns outliers. The Burnside and Dollar specification excludes five observations that are highly influential with respect to the coefficient on their aid*policy variable. This raises the general question about the extent to which significant results in this literature are driven by outliers. As a robustness test, we run at first a classical 2SLS regression in which we flagged outliers using the Cook's D statistics. Hence, we dropped from our sample observations for which the Cook'D was higher than the conventional threshold of *4/n*, with *n* the original number of observations. Then we apply our main estimation strategy to this cleared sample (22 outliers discarded out of 393 observations, see Table 2 for details). As the results do not seem conditioned on outliers exclusion, we only report results from the full sample.

4 – Estimation results

<Table 1 about here>

In the first column we test our alternative specification using generalized additive partially linear model. We choose to rely on thin plate regression splines with shrinkage as basis for our GAPLM formulation. Our sample being relatively small the nice properties of this basis are not offset by the computational costs. Using a χ^2 - test comparing the deviance between the full model and the model without the nonlinear part, it appears that the smooth term is significant at the 5% level with a p-value of 0.02. In the same vein, Figure 1 also provides

Bayesian's confidence interval for the smooth term. Using our estimation strategy allow us to obtain a significant a more complex nonlinear pattern than specification with only a squared term on a large set of data.

<Figure 1 about here>

The first implication of this figure is that it confirms the Laffer curve view of Lensink and White [2001] as well as the minimum effort one of Gomanee et al. [2003]. Hence the aid to growth relationship is slightly decreasing (nearly constant and close to zero) for low level of aid flows. However, there is a turning point around 2% where the marginal returns increase. This pattern matches Gomanee et al. [2003] findings. There is a minimum level of aid flows for aid to efficiently stimulate economic growth. Our results seem to come in support of the "Big Push" theory requiring a scaling up of aid to overcome some kind of "poverty trap" or, at least, that only a large inflow of Aid might overcome structural rigidities or fixed costs implied by the management of aid, as we can not investigate on the reasons of such findings here. However, as aid flows reach around 5% of the country real GDP, marginal returns turn out again to be decreasing and, even if the significance level of our nonlinear trend decrease sharply, there are evidence that an increase of aid might become harmful to growth for a high level of ODA to GDP ratio (around 6%) everything equal. This second point confirms the former idea that aid beyond some level displays diminishing returns leading to an aid "Laffer curve": reflecting a limited absorptive capacity of recipient countries, due to capacity constraints, "Dutch disease" reactions or any other factors (as analyzed in Guillaumont and Guillaumont Jeanneney 2006a, 2006b). The overall conclusion we can drawn from this figure is that even if the pattern of the curve supports our hypothesis of multiple thresholds, only a small part of the aid distribution seems to be only effective with regard to growth as it is located around the second thresholds according to the confidence interval. Nevertheless, we have to keep in mind that the Net ODA to GDP variable that we use is undoubtedly a very “mixed bag” and that we have to expect the significance level to be quite low as every aspects of aid do not have a direct impact on growth.

As previously mentioned, a substantial part of the aid-effectiveness literature argues that donors should concentrate their effort on countries with “good policies”. In Figure 2, we try to investigate how the aid-growth relationship changes with the quality of policies led by recipient countries. We follow Burnside and Dollar [2000] to build up our policy variable [2].

Instead of estimating a linear coefficient for the policy variable and the smooth function $f(Aid)$, we now specify a smooth function of two arguments $f(Aid, Policy)$. The convenience and flexibility of the GAPLM formulation is made quite clear in that case compared to a more classical 2SLS estimation for which we would have to include arbitrarily numerous multiplicative and squared terms. As the two variables are not on the same scale, we do not expect that the same degree of smoothness is appropriate with respect to both covariate axes. Hence, we choose to rely on tensor product smooth rather than on isotropic smooth. The smooth of the function $f(Aid, Policy)$ is then a tensor product of two thin plate regression splines with shrinkage basis.

The fourth column of Table 2 and Figure 2 display estimation results. For the sake of visibility, we choose not to report the confidence interval in the figure (available upon request). Our results can be compared with those of the existing literature. As stated by Burnside and Dollar [2000], aid seems more efficient in country implementing good policies. Indeed, and consistently with the traditional view, it appears that good economic policy makes aid less likely to harm growth at low level of aid and lead to a growth response to aid which is at its maximum level far above the one when less efficient policies are considered. Meanwhile, because marginal returns are negative on a wider range at low level of aid, countries running those kinds of policies need a higher level of aid to reach the area of marginal positive returns (and experiment an effective big push).

Moreover they seem to be able to sustain efficiently higher level of aid relative to their real GDP, suggesting a higher absorptive capacity. Then, on average, countries with weak economic policies can still hope to experience growth enhancement for relatively high level of aid. This can be interpreted as an effect of aid on institutions, as enlightened by Chauvet and Guillaumont (2004) in a different framework, an effect denied by Burnside and Dollar. From this second figure it does appears that thresholds seem to be state dependent on the quality of economic policy. Countries implementing good policies reach the area of positive marginal growth returns earlier than countries with less efficient policies (the first threshold even disappears as policy quality rise), then they experiment decreasing marginal returns earlier (at around 3% instead of around 6%): countries with bad economic policies could thus exhibit positive returns of aid, for a high aid level, when countries with good policies do not.

It so appears that thresholds in aid effectiveness are also conditional on the recipient countries specific features already highlighted by the literature. As we mentioned, in addition to the policy focused studies by Burnside and Dollar [2000], interaction between aid effectiveness and economic vulnerability has also received an important attention. Guillaumont and Chauvet [2001] and Chauvet and Guillaumont [2004, 2007] state the economic vulnerability of aid receiving countries is one of the main factors conditioning aid effectiveness. For countries suffering from such vulnerability, foreign aid allows dealing more efficiently with the effects of negative shocks. Aid is then supposed to smooth public expenditures, to stabilize budget balance and to some extent to avoid economic and social collapses, which may often result from shocks in low income countries. Accordingly, the marginal returns of aid must be higher for the most vulnerable countries. Or they may be less rapidly decreasing, as evidenced from an analysis of the factors determining the rate of success of World Bank projects (Guillaumont and Laajaj 2006).

<Figure 2 about here>

To build up a vulnerability variable, we use, as a proxy, the instability of total exports of goods and services in 2000 US Dollars from the World Bank. We use an instability indicator on 12 previous years with regard to a single rolling adjustment covering at least 12 years (as calculated at CERDI) and take the averaged value to match the four years periods of our panel. We include this variable in our specification, EXPVOL. As earlier, we now define our smooth function as $f(Aid, Expvol)$. The results, using the same basis, are reported in the final column of Table 2.

<Figure 3 about here>

It is rather difficult to draw conclusion from the analysis of the returns of aid when vulnerability is relatively low, as the marginal returns do not exhibit clear thresholds. Nevertheless, for countries that are less vulnerable it appears that aid impact is limited and close to zero as it rises above 2% and that the marginal returns are becoming close from constant. The understanding of non-linearities in the aid/growth relationship for vulnerable countries is, on the opposite, clearly an important issue.

Countries that are vulnerable display some very interesting non-linearities in the aid/growth relationship. We saw earlier that two distinct thresholds characterized this relationship and, more particularly that, at low level of aid, countries experience negative marginal returns. It then appears that it is not the case when economic vulnerability is high. Between zero and two percent of aid to real GDP, the marginal returns are still slowly increasing and the growth response is unexpectedly close from the low volatility case. Above two percent the pattern change and marginal returns rise, until around 4%, and become negative only as aid goes above 6%. If absorptive capacity is still an issue here, the stabilizing effects of aid is visible at low level of aid as there is no minimum effort from the donors to get positive return of aid.

Here again, it appears that the optimum level of aid and the implied thresholds are varying with economic conditions. However, from those results it is difficult to draw any conclusions about the dynamic behind this particular relationship. One intuitive way to deal with this issue is to once again modify slightly our specification and to estimate $f(AID, Lgdp)$. Our intuition is simple: As aid will strengthened the growth process, the GDP per capita level should rise mechanically. Hence, as the thresholds seem to depend on economic condition we should be able to see how their level and nature vary as recipient countries gets richer and escapes poverty.

As can be seen on Figure 4, which presents the estimate of the smooth function $f(AID, Lgdp)$, there are two distinct thresholds when LGDP is low (the natural logarithm of the real GDP per capita). The first one seems to support the big push theory. Indeed, to witness positive marginal returns aid has to be higher than 2% of real GDP. The dynamic of that threshold is also very interesting and comforts our hypothesis. As LGDP rises over 7.5, which is also the sample median for LGDP, this first threshold disappears. If we combine those findings with the fact that 75% of our observations display aid values below 2%, it certainly helps to understand why it is difficult to draw clear conclusions on the way aid supports or hinders the growth process or to find evidence backing up the "Big Push" theory with the commonly used econometric techniques, as most of the observations are being clustered in the bottom left quarter of the figure.

The dynamic of the second threshold also presents a very interesting pattern, close form the one suggested from the study of $f(AID, Policy)$. Countries with lower GDP per capita have to receive relatively more aid to reach that second threshold and experience the maximal growth response to aid.

<Figure 4 about here>

Nevertheless, as aid goes over 6%, countries run into some limited capacity constraint that appears to be harmful to growth. Furthermore, as their GDP rises, they seem to face that constraint earlier, as aid almost reaches 4% of the real GDP.

The main conclusion we can draw from this particular figure, that also supports our previous results, is that one must be very aware of the nature and level of the different thresholds in the aid/growth relationship for the design of the optimal aid allocation.

5 – Conclusion

Concluding a paper, Hansen and Tarp [2001] stated that *"We also note that empirical conclusions about aid effectiveness that are based on cross-country growth regressions depend on poorly understood nonlinearities and critical methodological choices"*. Alternatively, Guillaumont and Guillaumont Jeanneney [2006a] highlighted that the inclusion of an aid-squared term (and a cubic one) in the classical aid/growth equation was not appropriate to uncover the nature of the non-linearities crucial for this particular relation. Our attempt to address the nonlinear pattern of the aid growth relationship may overcome some of the main drawbacks highlighted so far. The methodology presented here allows us to investigate graphically on non-linearities without making any assumptions on the nature of the nonlinear trend. Our findings lead to augment results from Burnside and Dollar [2000], Lensink and White [2001] and Gomanee et al. [2003] altogether within a common empirical framework. We show that the aid / growth relationship is highly nonlinear with two clear thresholds. The first one confirms the view of researchers backing up the “big push” theory. It appears that many countries do not experience positive marginal returns from aid because they are just not receiving enough of it. As a matter a fact, for the period ranging from 1970 to 2001, the majority of countries seems to be trapped in a situation where the aid they receive do more harm than good. If we take the ODA to real GDP value for our last period, 1998-2001, only 10 countries out of 60 received enough aid to witness, everything equal, a significant and positive growth response. Nevertheless, as there exist a second threshold that confirm the hypothesis of limited absorptive capacity, our results also suggest that for very high level of aid the marginal returns after decreasing might become negative. However, this statement must be considered with extra caution as we show that these thresholds are conditioned by the implementations of "good" economic policy in recipient countries or by its economic vulnerability. If our results confirm that aid is more useful in good policy environment provided, it does not do so above a particular threshold. It is also worthwhile mentioning that aid might display increasing returns despite less efficient politics. This reinforces the view that the aid allocation rules relying mainly on policy rating should, as argued by Hansen and Tarp [2001] and many authors, be considered with a lot of circumspection. Furthermore, the level of country economic vulnerability appears to be critical to understand how growth responds to aid flows. Our results support the view that aid is more useful in countries where vulnerability is high. They also point out that those country do not seem to suffer from possibly negative returns of aid when this one is at a low level, as aid stabilizing effect help to deal with exogenous shocks. Finally, our results, by showing how those thresholds are modified as countries are escaping poverty, clearly define the aid/growth relationship as a complex dynamic process and help us to understand the difficulties that the literature faces in its numerous attempts to estimate this particular relationship.

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Notes

[1] This set of instruments has been extensively criticized (Rajan and Subramanian [2007] among others). Alternative instruments have been proposed. (see Tavares [2004], Guillaumont & Laajaj [2006])

[2] They used a linear combination of our three policy terms (budget surplus, inflation and openness) as: *Policy = 1.28 + 6.85.BB – 1.4.INFL + 2.16.SACW.*

Data sources (see Roodman [2007] for complete description)

Variable	Code	Data source	Notes
Per-capita GDP growth	GDPG	World Bank, 2003	
Initial GDP per capita	LGDP	Summers and Heston, 1991, updated using GDPG	Natural logarithm of GDP/capita for first year of period; 1985 constant dollars
Ethno-linguistic fractionalization, 1960	ETHN	Roeder, 2001	Probability that two individuals will belong to different ethnic groups
Assassinations/capita	ASSAS	Banks, 2002	Assassinations/capita
Institutionnal quality	ICRGE	PRS Group's IRIS III data set (see Knack and Keefer, 1995)	Revised version of variable. Computed as the average of three components still reported after 1997
M2/GDP, lagged one period	M21	World Bank, 2003	
Budget surplus	BB	World Bank, 2003; IMF, 2003	World Bank primary data source. Additional values extrapolated from IMF using series 80 and 99b (local currency budget surplus and GDP)
Inflation	INFL	World Bank, 2003; IMF, 2003	Natural logarithm of 1+inflation rate.
Sachs-Warner updated	SACW	Sachs and Warner, 1995; Easterly et al., 2004; Wacziarg and Welch, 2002	
Net Overseas Development Assistance/real GDP	AID	DAC, 2002; World Bank, 2003	
Population	LPOP	World Bank, 2003	Natural Logarithm
Arms imports/total imports lagged	ARMS1	U.S. Department of State, various years	
Volatility of exportation of goods and services	EXPVOL	World Bank, 2006 Cerdi, 2007	2000 constant dollars. on 12 previous years with regard to a single rolling adjustment covering at least 12 years

Table 1: Estimation results

	Dependant variable: 4-years growth rate			
	(1)	(2)	(3)	(4)
LGDP	-0.1023	-0.0103	0.1995	-
	(0.3428)	(0.3492)	(0.3692)	
ICRGE	0.3874***	0.3407***	0.3944***	0.3933***
	(0.1058)	(0.1079)	(0.1237)	(0.1025)
INFL	-3.2941***	-	-3.0214***	-3.0525***
	(0.8489)		(0.8779)	(0.8374)
BB	9.0263**	-	8.9590**	9.5387**
	(3.8316)		(4.1391)	(3.7353)
SACW	0.8232*	-	0.8957**	0.8538**
	(0.4284)		(0.4520)	(0.4115)
M21	0.0054	0.0160	0.0076	0.0080
	(0.0121)	(0.0118)	(0.0134)	(0.0117)
ETHNF	-0.5407	-0.6103	-0.3749	-0.6653
	(0.7215)	(0.7157)	(0.7673)	(0.7002)
ASSAS	-0.4479*	-0.4834**	-0.3352	-0.4375*
	(0.2279)	(0.2277)	(0.2352)	(0.2229)
ETHNASSAS	0.9672*	0.9376*	0.7367	0.8820*
	(0.5097)	(0.5131)	(0.5228)	(0.4946)
$f(AID)$				
Approximate significance of the smooth term.	0.0275	-	-	-
Estimated degrees of freedom	3.678			
	Aid effectiveness conditional to economic policy			
$f(AID, Policy)$				
Approximate significance of the smooth term.	-	0.0000	-	-
Estimated degrees of freedom		14.91		
	Aid effectiveness conditional to exports volatility			
$f(AID, Expvol)$				
Approximate significance of the smooth term.	-	-	0.0737	-
Estimated degrees of freedom			8.462	
	Aid effectiveness conditional to initial GDP			
$f(AID, Lgdp)$				
Approximate significance of the smooth term.	-	-	-	0.0045
Estimated degrees of freedom				4.541
Number of observations	389	389	330	389
Adjusted R-squared	0.36	0.36	0.35	0.38
% of explained deviance	39.8	41.1	40.3	41.1

Regressand is per capita GDP growth. Each regression includes a constant term, as well as period and regional dummies, which are not reported. Column (1), (2), (3) and (4) are estimated using GAPLM formulation. AID corresponds to the first step fitted value of our original aid variable.

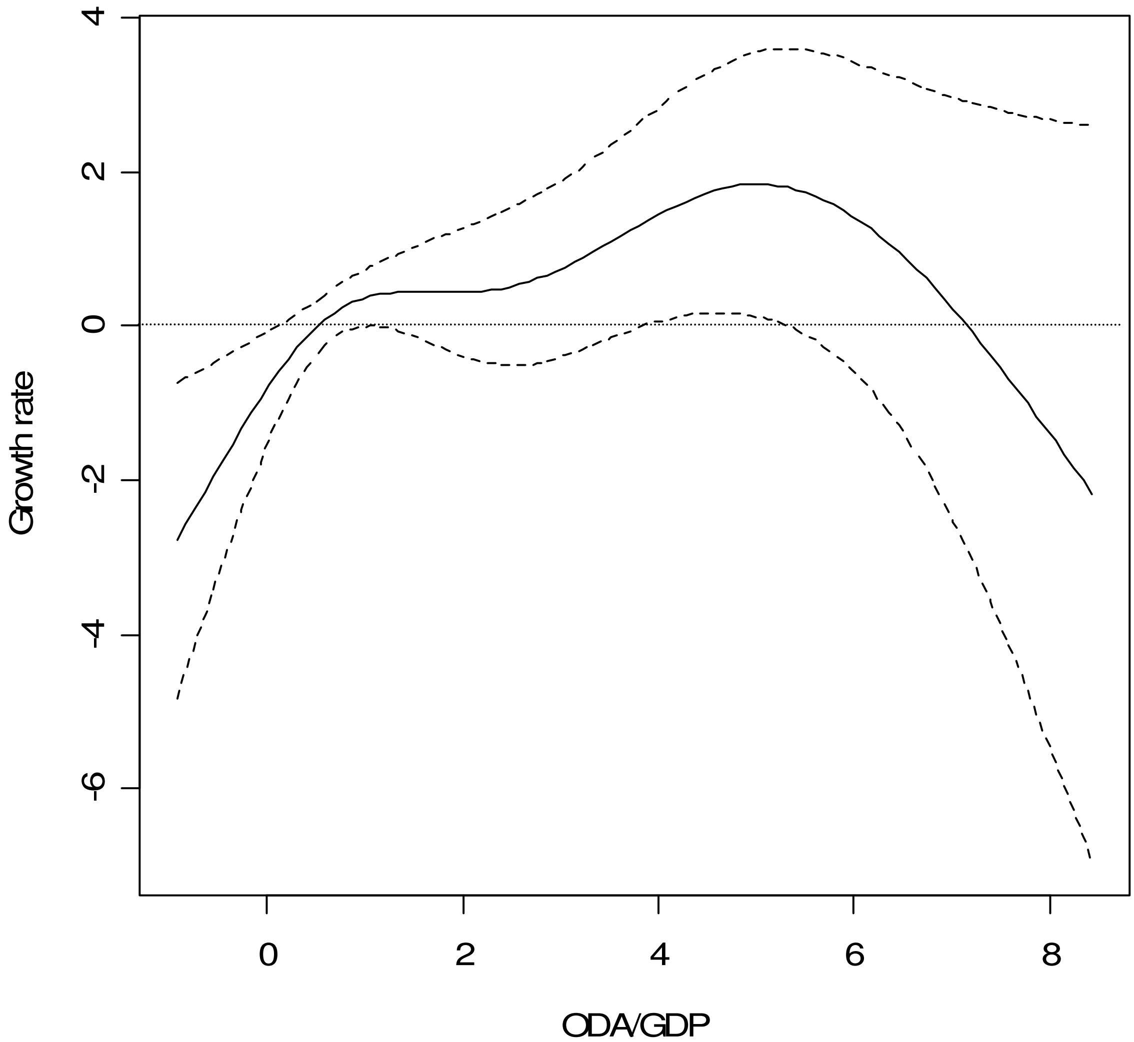
As stated before, the exclusions of outliers from our sample does not change much the results. In this particular case it even strengthens our conclusions as the significance level rise and the first threshold appears more clearly.

Table 2: Country list

Algeria	Ecuador	Malawi	South Africa
Argentina (3, 7)	Egypt Arab Rep.	Malaysia	Sri Lanka
Bolivia	El Salvador (4)	Mali	Syrian Arab Rep. (3)
Botswana (6)	Ethiopia	Mexico	Thailand
Brazil	Gabon (3, 4)	Morocco	Togo (7)
Burkina Faso	Gambia, The (6, 7)	Myanmar	Trinidad and Tobago
Cameroon	Ghana	Nicaragua (4, 6, 7)	Tunisia
Chile	Guatemala	Niger	Turkey
China (8, 9)	Haiti (7)	Nigeria (2)	Uganda
Colombia	Honduras	Pakistan	Uruguay
Congo Rep.	India	Paraguay	Venezuela
Congo Dem. Rep. (7)	Indonesia	Peru	Zambia
Costa Rica	Jamaica	Philippines (5)	Zimbabwe
Cote d'Ivoire	Kenya	Senegal	
Cyprus	Korea Rep.	Sierra Leone (8)	
Dominican Republic	Madagascar	Singapore	

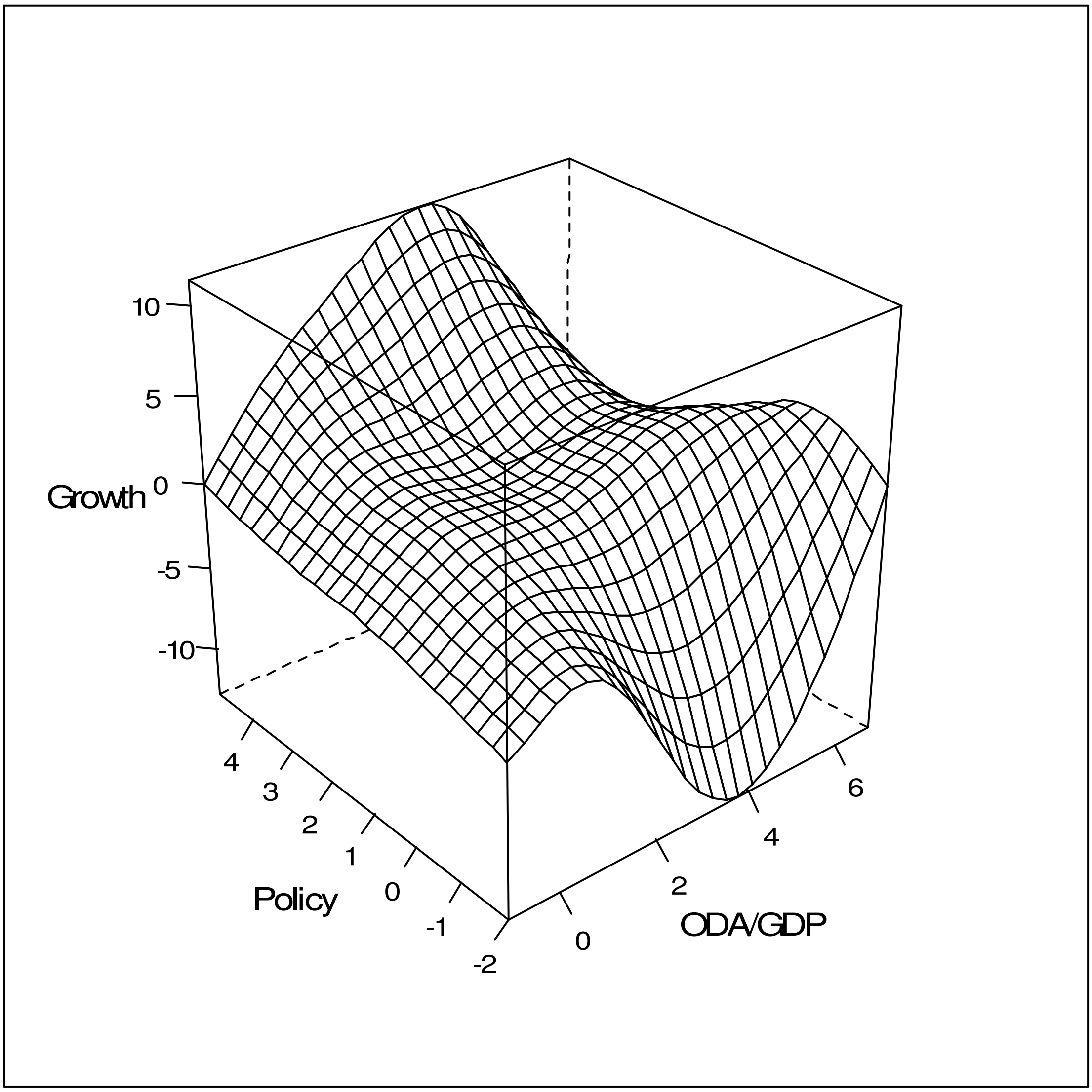
Periods where countries are identified as outliers are in parenthesis. 3 stand for the 1974-1977, 4 for 1978-1981, 5 for 1982-1985, 6 for 1986-1989, 7 for 1990-1993, 8 for 1994-1997.

Figure 1: Estimation of the nonlinear effect of aid on GDP growth



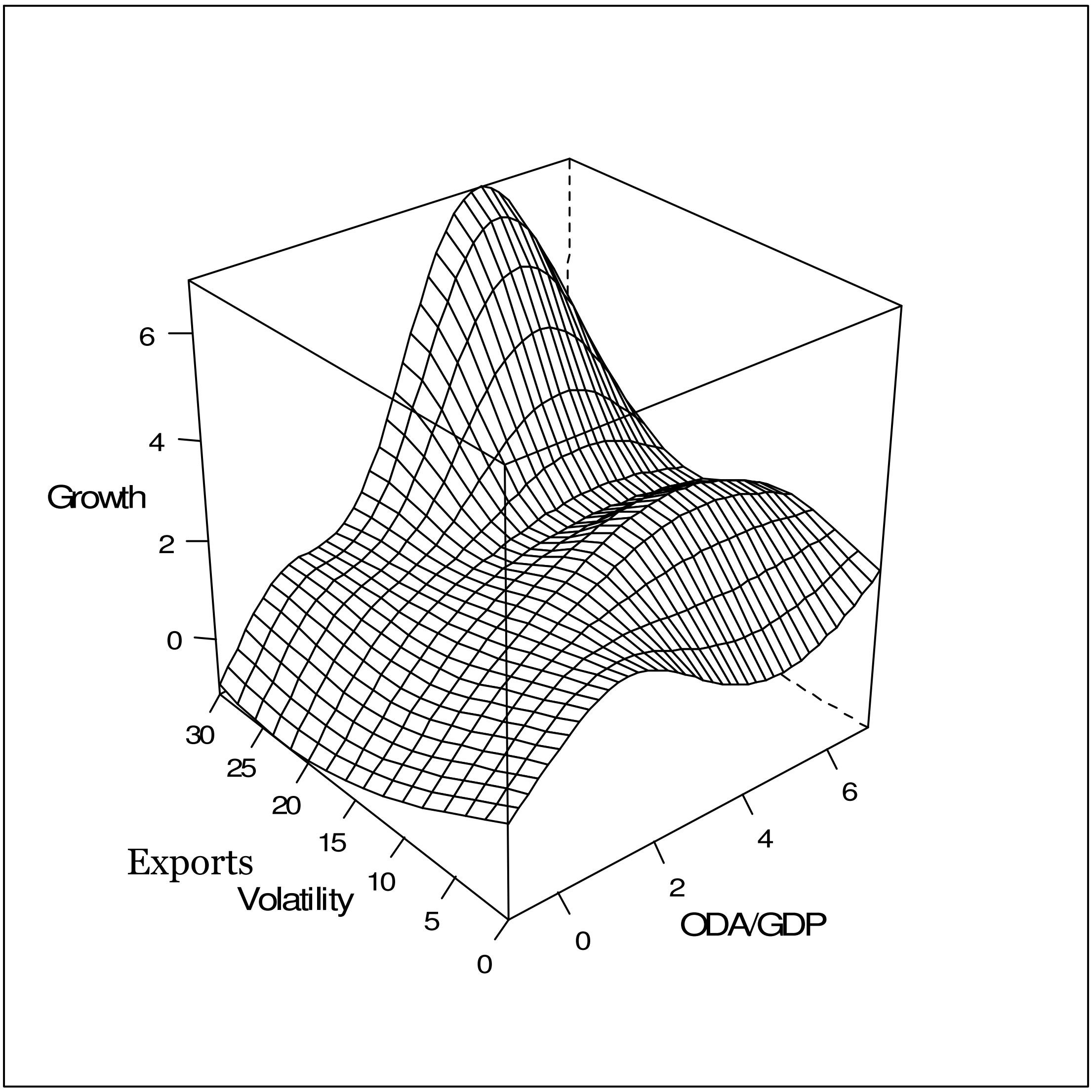
The graph shows the estimate of the function $f(AID)$ using GAPLM with thin plate regression splines (with shrinkage) as basis. The dashed curves represent the 5% Bayesian's confidence interval. (Source: author calculations)

Figure 2: Aid marginal impact with respect to policy quality



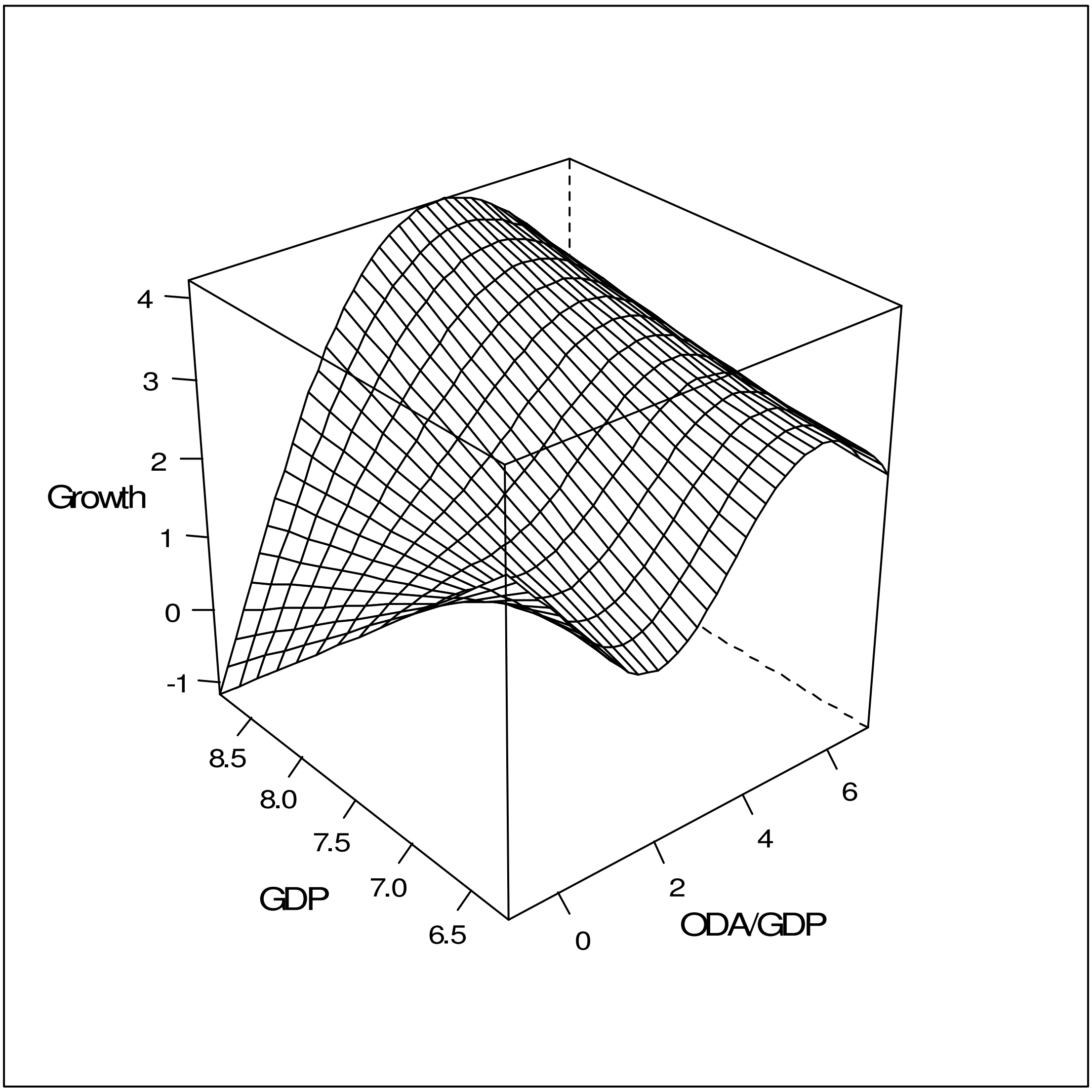
The graph shows the estimate of the function $f(AID, Policy)$ using GAPLM, with tensor products of thin plate regression splines (with shrinkage) as basis, on the space of available data. The parametric variables of the estimated equation are evaluated at their sample mean. The Bayesian's confidence interval is not reported for the sake of visibility. (Source: author calculations)

Figure 3: Aid marginal impact with respect to exports volatility



The graph shows the estimate of the function $f(AID, Expvol)$ using GAPLM, with tensor products of thin plate regression splines (with shrinkage) as basis, on the space of available data. The parametric variables of the estimated equation are evaluated at their sample mean. The Bayesian's confidence interval is not reported for the sake of visibility. (Source: author calculations)

Figure 4: Aid marginal impact with respect to the logarithm of initial GDP



The graph shows the estimate of the function $f(AID, Lgdp)$ using GAPLM, with tensor products of thin plate regression splines (with shrinkage) as basis, on the space of available data. The parametric variables of the estimated equation are evaluated at their sample mean. The Bayesian's confidence interval is not reported for the sake of visibility. (Source: author calculations)

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