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Measuring Aid Effectively in Tests of Aid Effectiveness[§]

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Abstract

In the extensive empirical literature on aid effectiveness, aid is always measured as a share of GDP. However, measuring aid in real dollars *per capita* is also consistent with standard growth theory. We show that the choice of denominator makes an enormous difference to the sign and significance of coefficients on aid variables in cross-country panel growth regressions. Our aim is to redirect attention towards the theoretical foundations of the growth literature.

JEL classification: O19, O40

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1. Introduction

It is with some trepidation that we step into the battlefield that the aid-growth literature has become. Since the publication of Burnside and Dollar (2000) (henceforth B&D) there has been a very lively debate on the factors that determine the effectiveness of foreign aid, and in particular on the role played by recipient government policy and institutional quality. Several recent papers present evidence in support of the original B&D result, that the beneficial effects of aid are largely confined to countries with healthy policy environments; these papers include Collier and Dehn (2001) and Burnside and Dollar (2004). B&D is extensively cited in the academic literature and has had an enormous impact on policy-makers (*The Economist*, 01.13.2007, page 67). Two sets of papers challenge the B&D result, but for very different reasons. On the one hand are those such as Easterly *et al*. (2004), who argue that there is not yet any robust evidence that aid promotes economic growth, even in "good" policy environments. On the other hand are authors such as Dalgaard and Hansen (2001), who contend that there is clear evidence that aid promotes growth (albeit with diminishing returns), regardless of the policy environment. McGillivray *et al*. (2006) provide an overview of the wide range of results to be found in recent papers, and Doucouliagos and Paldam (2006) conduct a meta-analysis of these results.

A large part of the debate revolves around the effect of changes in sample size and estimation technique on aid coefficients in regressions of *per capita* GDP growth rates on the lagged level of *per capita* GDP and a set of conditioning variables, usually using panel data for a set of developing countries. In this paper we show that the results of aid-growth regressions are sensitive to yet another permutation, that is, changing the denominator used to scale the aid variable. We are well aware that the world already contains a multitude of growth regressions, and our aim is not to produce "better" estimates of the aid-growth relationship. Rather, we wish to show that more attention needs to be paid to growth theory in constructing and interpreting regression equations. There has been little discussion of economic theory in the existing literature. A few papers such as Dalgaard *et al*. (2004) include a theoretical model of aid and growth, but the theory is not closely tied to the subsequent regression equations, and does not provide a guide to the functional form of the regressions. We begin with our alternative set of regression results, and then move on to the theoretical interpretation.

2. Empirics

Our empirical analysis uses B&D as a benchmark. We employ the same panel data set as B&D, and use the same estimation techniques to replicate their results.[1] The only change we make is to the way that aid is measured. B&D – and every other empirical paper we are aware of – measure aid as a fraction of recipient GDP; we measure aid in real PPP-adjusted international dollars *per capita*. We construct this measure by scaling the B&D aid measure for country *i* in period *t* by the average value of *i*'s real *per capita* GDP in international dollars during period *t*. The *per capita* GDP data are taken from the same version of the Penn World Tables as that used in B&D.

Our results are presented in Tables 1-2 alongside the original B&D results. In all cases, the dependent variable is the percentage rate of growth of the real international dollar value of *per capita* GDP in country *i* over period *t*. The set of regressors includes the initial (log) level of *per capita* GDP plus a range of conditioning variables, including fixed time effects, a measure of ethnic fractionalization, the number of political assassinations *per capita*, a measure of institutional quality, the lagged ratio of M2 to GDP and region dummies for Sub-Saharan Africa and East Asia. All of the regressions also include the B&D measure of policy quality (a weighted average of figures for the budget balance, inflation and the Sachs-Warner openness index.) and a measure of aid: either aid as a fraction of GDP or aid *per capita* in international dollars. The correlation between aid *per capita* and aid as a share of GDP is 0.73: the two series are highly, but far from perfectly, correlated. In Table 1, which corresponds to Table 4 (columns 3-4) in B&D, this basic regression specification is complemented by an expanded model that includes the aid measure interacted with policy and the square of the aid measure interacted with policy. In Table 2, which corresponds to Table 4 (column 5) in B&D, the squared aid term is absent, but a number of outlier observations are excluded from the sample.

Tables 1-2 here

[1] We do not replicate every single regression reported in B&D, but focus on their basic model, fitted using OLS, and on their "preferred" model in which the Hadi method was used to exclude outliers; we exclude the same five observations as B&D. There is a small but statistically significant negative correlation between aid *per capita* and GDP *per capita* (r = -0.18). It is possible that endogeneity biases our *per capita* aid coefficients downwards; if so, the results presented in Tables 1-2 understate our case.

If we measure aid as a fraction of GDP then it is statistically significant only when interacted with the policy variable; this is the original B&D result. In the B&D model in Table 1, there is a significant positive coefficient on aid interacted with policy and a significant negative coefficient on aid squared interacted with policy, suggesting that aid is effective (with decreasing returns) in good policy environments. In poor policy environments, the effect of aid is negligible. When the outliers are removed (Table 2), the squared aid term is redundant but the results are otherwise very similar: unless aid is interacted with policy, it does not appear to be a significant explanatory variable.

The two tables show that if aid is measured differently then the results are completely different. Aid *per capita* does have a significant positive coefficient, even in the absence of any interaction terms. Our estimate of the coefficient on aid *per capita* is around, 0.02 implying that a $100 increase in aid *per capita* would raise the rate of *per capita* economic growth by two percentage points.

When aid *per capita* interaction terms are included in Table 1, they too have significant coefficients, but with the opposite signs to those in B&D. (The fitted coefficients on the interaction terms are very much smaller than in B&D, but this is the result of an arbitrary scaling of *per capita* aid.) The aid-policy interaction term in Table 2 is not significant at all. If the *per capita* aid results had predated B&D, one might have concluded that aid does have a significant impact on growth, even in countries with poor policy regimes, and that policy has at most a marginal impact on aid effectiveness.[2] Coming after B&D, the new results are a puzzle. How can a minor adjustment to the way that aid is measured have such a large impact on the regression results? The answer lies in some simple growth theory, as explained in the next section.

3. Theory

When aid effectiveness papers refer explicitly to a theoretical model (as in Dalgaard *et al*., 2004), aid enters the model in *per capita* terms, either as a transfer to the representative

[2] However, this statement needs to be treated with some caution. Policy by itself is highly significant in all of the regressions in Tables 1-2. So even if a $1 increase in aid *per capita* is associated with the same percentage increase in steady-state *per capita* GDP regardless of policy, this percentage will still represent a larger absolute dollar increase *per capita* in countries with better policy and therefore higher initial GDP levels.

consumer appearing in the household budget constraint, or as an addition to domestic savings in the economy's resource constraint. Of course, the theory can be expressed equally well by measuring aid as a fraction of GDP as it can by measuring aid *per capita*. Take a simple textbook overlapping generations model (as for example in Romer, 1996, chapter 2), in which the resource constraint is

$$k_{t+1} = [s_t \cdot w_t] / [1 + n] \tag{1}$$

where k_t is the capital-labor ratio in period t, s_t the household savings rate, n the rate of growth of the working population and w_t the equilibrium wage rate. Assuming a logarithmic utility function and a Cobb-Douglas production function with a fixed technology, we can derive an equation of motion for output per worker:

$$y_{t+1} = [\beta \cdot y_t]^{\alpha} \tag{2}$$

where $\beta = [1 - \alpha] / \{[1 + n] \cdot [2 + \rho]\}$, α representing the Cobb-Douglas parameter and ρ the rate of impatience. This equation implies a growth regression of the form:

$$\Delta\ln(y_{t+1}) = \alpha \cdot \ln(\beta) - [1 - \alpha] \cdot \ln(y_t) \tag{3}$$

In empirical growth regressions, the constant β is replaced by a range of variables capturing the determinants of factor productivity, for example, the conditioning variables in Tables 1-2. In addition, we can easily add an aid term to equation (1):

$$k_{t+1} = [s_t \cdot w_t + x_t] / [1 + n] \tag{4}$$

where x_t is to be interpreted as an exogenous resource inflow per worker. Equation (2) becomes:

$$y_{t+1} = \{\beta \cdot y_t + x_t / [1 + n]\}^{\alpha} \tag{5}$$

However, it is also possible to rewrite this equation in terms of aid as a fraction of output. Let $z_t = x_t / y_t$; then we have:

$$y_{t+1} = \{[\beta + z_t / [1 + n]] \cdot y_t \}^{\alpha} \tag{6}$$

In neither equation (5) nor equation (6) is y_{t+1} a log-linear function of β, y_t and aid. Linear regression equations are then to be interpreted as approximations to the theoretical model. This little wrinkle becomes more serious when we consider growth regressions that incorporate an interaction term, for example, aid interacted with policy, as in Tables 1-2. The usual interpretation of such non-linear regressions is that the interaction term reflects a mechanism through which the effectiveness of aid is modified by policy. However, another interpretation is that the interaction term is really picking up non-linearities in a simpler growth model, such as the one represented by equations (5-6). In this case, the significance of an interaction term does not *necessarily* mean that policy impacts directly on aid effectiveness.

Note also that the form of the non-linearity in equation (5) is different from the one in equation (6). If these equations do represent the true model, regression equations incorporating aid *per capita* should not exhibit the same non-linearities as ones incorporating aid as a fraction of GDP. It is therefore not surprising that when we fit two regression equations, one with aid *per capita* and one with aid as a fraction of GDP, and find that they exhibit different non-linearities. This is not to say that the correct model of growth is necessarily represented by equations (5-6), with a linear function of the Table 1 regressors standing in for β. It is still possible that productivity depends on other explanatory variables, or that productivity is itself a non-linear function of the regressors (including aid interacted with policy). However, the theory suggests that a log-linear growth regression is an inappropriate conceptual starting point, and that a great deal of caution is needed when interpreting any non-linearities that appear. It also indicates a necessary condition for the validity of an empirical growth model: that one should be able to express the model in terms of aid *per capita* and in terms of aid as a fraction of GDP, fit both forms of the model to the data, and produce theoretically consistent results.

4. Conclusion

The sign and significance of coefficients on foreign aid variables in cross-country panel growth regressions is very sensitive to the way that aid is measured. Including terms in aid *per capita* instead of aid as a fraction of GDP completely changes the results. This discrepancy casts doubt on some traditional interpretations of aid-growth regressions. We suggest that the discrepancy is consistent with standard growth theory. Reference to this theory should be an important part of the construction and interpretation of future studies of the impact of aid on growth.

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Table 1: B&D Regressions Compared with *Per Capita* Aid Regressions

Standard errors are in parentheses.

*** indicates significance at the 5% level; * indicates significance at the 10% level.*

	B&D		aid *per capita*		B&D		aid *per capita*	
	coeff.	(s.e.)	coeff.	(s.e.)	coeff.	(s.e.)	coeff.	(s.e.)
Initial GDP	-0.61	(0.56)	-0.73	(0.49)	-0.56	(0.56)	-0.78	(0.50)
Ethnic Fractionalisation	-0.54	(0.72)	-0.29	(0.74)	-0.42	(0.73)	-0.38	(0.75)
Assassinations	-0.44	(0.26)*	-0.44	(0.27)*	-0.45	(0.26)*	-0.45	(0.27)*
Ethnic × Assass.	0.82	(0.44)*	0.84	(0.44)*	0.80	(0.44)*	0.85	(0.44)*
Institutional quality	0.64	(0.17)**	0.74	(0.17)**	0.67	(0.17)**	0.70	(0.17)**
M2/GDP	0.014	(0.013)	0.002	(0.010)	0.016	(0.014)	-0.002	(0.010)
Sub-Saharan Africa dummy	-1.60	(0.73)**	-2.16	(0.67)**	-1.84	(0.74)**	-2.10	(0.67)**
East Asia dummy	0.91	(0.54)*	1.11	(0.57)**	1.20	(0.58)**	0.91	(0.60)
Policy	1.00	(0.14)**	0.95	(0.14)**	0.78	(0.20)**	1.14	(0.23)**
Aid	0.03	(0.12)	0.022	(0.01)**	0.49	(0.12)	0.02	(0.01)*
Aid × policy					0.20	(0.09)**	-0.02	(0.01)*
Aid^2 × policy ÷ 100					-1.9	(0.8)**	0.02	(0.01)*
R^2	0.392		0.410		0.398		0.417	
N	275		275		275		275	

Table 1: B&D Regressions Compared with *Per Capita* Aid Regressions (Restricted Sample)

Standard errors are in parentheses.

*** indicates significance at the 5% level; * indicates significance at the 10% level.*

	B&D		aid *per capita*	
	coeff.	(s.e.)	coeff.	(s.e.)
Initial GDP	-0.60	(0.57)	-0.85	(0.49)*
Ethnic Fractionalisation	-0.42	(0.72)	-0.25	(0.75)
Assassinations	-0.45	(0.26)*	-0.45	(0.27)*
Ethnic × Assass.	0.79	(0.44)*	0.85	(0.44)*
Institutional quality	0.69	(0.17)**	0.79	(0.17)**
M2/GDP	0.012	(0.014)	0.000	(0.02)
Sub-Saharan Africa dummy	-1.87	(0.75)**	-2.35	(0.69)**
East Asia dummy	1.31	(0.58)**	1.22	(0.59)**
Policy	0.71	(0.19)**	0.86	(0.20)**
Aid	-0.021	(0.16)	0.027	(0.01)**
Aid × policy	0.19	(0.07)**	0.002	(0.005)
R^2	0.394		0.410	
N	270		270	