Effectiveness of Aid on Growth in Dynamic Heterogeneous Panels: Evidence from Africa*

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Abstract

This paper examines the relationship between foreign aid, economic policies, and growth in real GDP per capita amongst Sub-Saharan, Middle, and North-Eastern African countries during the period 1976 - 2004. Unlike earlier studies, this paper investigates both long- and short-run impact of aid on growth using the pooled mean group methodology. The long-run impact of aid on growth is found to be negative and conditioning aid on 'good' policy has marginal effect on the long-run growth rate. Policy simulations conducted based on estimated heterogeneous short-run coefficients show that, on average, the effectiveness of aid could be positive in the short run.

Keywords: aid impact; economic growth; pooled mean group estimators; dynamic heterogeneous panel estimator.

JEL classification: O11; O2; O43.

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1 Introduction

The question on aid effectiveness has often been examined using cross-country growth regression analyses. One of the key findings in the nexus between foreign aid and growth in real GDP per capita is that aid has positive impact on growth when it is interacted with 'good' policy (Burnside and Dollar, 2000). Recent contributions (for example, *inter alia*, Easterly et al., 2004 and Hansen and Tarp, 2001), have re-examined this relationship and found that this result is not robust to the introduction of additional data, alternative specifications and estimation procedures. Hansen and Tarp (2001) have also explored the implication of quadratic terms in aid and policy together with the aid-policy interaction term.

Clearly, one of the highly debatable issue in the aid-growth regression literature is the treatment on the endogeneity of aid and its appropriate choice of instruments. Instead, this paper focuses on one aspect of the aid effectiveness literature which has received relatively less attention (see Tarp (2006) for discussion). This paper explores the validity of key findings in the literature by taking into account the fact that the impact of aid on growth is not the same across aid recipient countries. To do so, the pooled mean group (PMG) estimator, a dynamic heterogeneous estimation procedure, developed by Pesaran et al. (1999) was adopted. To investigate the influence of aid on growth, an annual dataset comprising of 19 African countries spanning the period 1976-2004 was assembled.[1] The specifications include variables commonly used in the traditional aid-growth literature. These include foreign aid, financial development, and a measure of policy (following Burnside and Dollar, 2000). In some specifications, quadratic terms in aid and policy are included following Durbarry et al. (1998), Hadjimichael et al. (1995), Hansen and Tarp (2001), and Lensink and White (1999). For sensitivity checks, countries are also classified as "poor" if the level of real GDP per capita level (2000 constant prices) is less than US$500, and "rich" if level of income is greater than US$500.

[1] The cross-section and time series dimension of the dataset is chosen with an eye to obtain a balanced panel. These countries are Algeria, Botswana, Cote d'Ivoire, Egypt, Gabon, Gambia, Ghana, Kenya, Madagasca, Morocco, Nigeria, Niger, Senegal, Sierra Leone, Sudan, Swaziland, Togo, Turkey, and Zimbabwe.

Besides being one of the first applications of this methodology on the analysis of foreign aid and growth, there are other advantages to the choice of the PMG procedure in the wider context of the growth empirical literature.[2] First, it allows for short-run heterogeneous dynamics but imposes a long-run homogeneous relationship for countries in the sample. Given that major aid-recipient countries are often seen to be stuck in perpetual poverty trap, it is highly likely that such a long-run relationship exists. In other words, this method allows one to assess the long-run relationship between growth and aid in accordance to practises in the empirical growth literature. Second, the speeds of convergence and short-run adjustment terms are allowed to vary across countries. There is little evidence to suggest that each individual country should converge to their long-run steady state equilibrium at the same rate. Third, the PMG estimates can be used to conduct policy experiments on the effects of a persistent increase in foreign aid. This allows one to disentangle the non-linear effects between aid and growth during the dynamic transition over time.

The key findings of this paper can be summarised as follows. First, the long-run effect of aid on growth is negative, and more importantly, the aid-policy interaction term is estimated to be close to zero. The quadratic terms in aid and policy are not statistically significant in the full data sample but is found to be important amongst the poorer countries. This suggests that the receipt of a critical level of foreign aid may lead to faster growth for poorer countries in the long run. Nevertheless, the policy variable is found to be positive and robust across specifications and country sub-groups. Second, the effects of individual components of the policy variable, that is government consumption, inflation and trade openness, are either estimated to have the wrong signs or small in its contribution to economic growth. Third, the policy experiment of a persistent aid shock shows that some countries do benefit from an increase in foreign aid in the short run albeit the negative long-run coefficient on aid. This finding highlights the importance of short-run heterogeneous characteristics of the countries in the sample. This result, however, depends on the functional form of the empirical growth

[2] Bassanini and Scarpetta (2002) have used the PMG estimator to investigate the role of human capital on growth.

regression.

The rest of the paper is organised as follows. Section 2 describes the econometric model and methodology. In Section 3, the PMG results under various specifications and various sub-groups of countries are presented. Section 4 presents some simulations and places some empirical magnitudes on the effect of a persistent positive aid shock on the growth rate of countries in the sample. Section 5 concludes.

2 Econometric Model and Methodology

Till date, the findings in the literature on foreign aid and growth remain mixed. The question on the importance of foreign aid is sensitive to the choice of regression specifications, cross-section sample of countries, time period considered, and the estimation procedure. Albeit the presence of numerous contributions, this strand of research has adopted panel estimator suited for data with large N and small T. These include the fixed effect estimator, the dynamic panel data estimator (see, for example, Arellano and Bond, 1991), and the instrumental variable approach.

As Pesaran et al. (1999) argue, the Arellano-Bond GMM technique leads to inconsistent estimates in heterogeneous dynamic panels, particularly when the time dimension, T, is large. So, there is a risk of misleading inferences about the true long-run relationship between foreign aid and growth. Moreover, the Arellano-Bond approach does not permit heterogeneity in the short-run adjustment process for various countries in the sample. This procedure also assumes the same speed of adjustments for all countries. Thus, this approach may not be helpful for donor countries in the decision making process on the level of external assistance to different recipient countries. Henceforth, the results attained till date may not be helpful in achieving one of the key objectives of the millennium development goals.

To appreciate the advantages of the PMG estimation procedure, it is important to understand the characteristic of common estimation procedures used in cross-country empirical growth analyses. First, in the traditional approach for estimating pooled unobserved effects models, intercepts are allowed to differ across groups while all other coefficients and error variances are constrained to be the same. The basic motivation for using panel data is to solve the problem of an omitted variable, that is, the time-invariant unobserved effect α_i of an individual country. Since individual countries are not randomly drawn from a population, a fixed effect model is suitable. The basic fixed effect model is:

$$y_{it} = \alpha_i + X_{it}\beta + u_{it},\ \ t = 1, ..., T,\ \ i = 1, ..., N.$$

where α_i's are unobserved heterogeneity terms, X_{it} is a vector of explanatory variables, and u_{it} the idiosyncratic error. For consistent estimates, the strict exogeneity assumption has to be fulfilled, that is, $E(X_{is}' u_{it}) = 0,\ s, t = 1, ..., T$. This also implies $E(u_{it}\alpha_i) = 0$. As $T \to \infty$, the α_i's can be precisely estimated. Since macroeconomic variables suffer from endogeneity problems and possible correlation between contemporaneous error and X_{it+1}, the strict exogeneity assumption may be violated.

The other common estimator used in the empirical growth literature is the Arellano-Bond (1991) dynamic panel estimator. In such models, the analysis is further complicated by the existence of lagged dependent variable on the right hand side of the estimated model. Adopting the standard estimation procedure from pooled models will yield biased estimates (Pesaran and Smith, 1995). Suppose there is a pooled regression:

$$y_{it} = \alpha_i + \lambda y_{it-1} + X_{it}\beta + u_{it}.$$

Under the standard assumption of fixed effect models, $E(u_{it}|X_{it,}\alpha_i) = 0$. In dynamic panels, this condition becomes $E(u_{it}|y_{it-1}...y_{i0},\ X_{it,}\ \alpha_i) = 0$ as lagged dependent variables are included as regressors. Since u_{it} is correlated with X_{it} which include lagged y_i, the pooled estimators will be inconsistent. Nickell (1981) also shows that even as N tends to infinity, the estimates are biased in autoregressive models with fixed effects because there is a correlation between y_{it-1} and ϵ_i.

The inconsistency problems in a dynamic panel can be resolved by choosing suitable instrumental variables (IV). Since the lagged dependent variable y_{it-1} is a regressor, appropriate IVs could be $y_{it-2}...y_{i0}$ as they are uncorrelated with the change in idiosyncratic errors. This problem is circumvented by considering the full range of IVs in the Generalized Methods of Moments (GMM) procedure (see Arellano and Bond, 1991). A prominent study, Hansen and Tarp (2001), has adopted this approach. However, Pesaran et al. (1999) argue that the Arellano-Bond dynamic panel estimator can lead to inconsistent estimates in a heterogeneous dynamic panel when T is large.

In view of the inconsistency problems associated with the abovementioned estimators under large N and large T dataset, Pesaran and Smith (1995) propose the mean group (MG) estimator to yield consistent estimates. The procedure is to estimate separate equations for each group and examine the distribution of the estimated coefficients across groups. Having determined the distribution of coefficients, the first moment yields the MG estimates. Nevertheless, this procedure may not be suitable since the group of under-developed African economies could have an identical long-run equilibrium relationship for their growth rate.

There are several statistical advantages to the deployment of the PMG estimator. It is an intermediate estimator which allows the intercepts, short-run coefficients, and error variances to be different across groups, but the long-run coefficients are constrained to be homogeneous across groups. There are good reasons to believe that the long-run equilibrium relationship amongst variables should be identical across groups, while the short-run dynamics are heterogeneous. As shown by Haque et al. (2000), this feature is critical since the failure to account for country heterogeneity in the short-run dynamics could result in misleading inferences on the determinants of the dependent variable. Finally, the null hypothesis of long-run slope homogeneity in the coefficients is tested using the Hausman test.

Following earlier studies, it is appropriate to estimate a standard growth equation following specifications closely related to Burnside and Dollar (2000). In the process of assembling a more complete and balanced panel dataset, there are several differences on the choice of variables on the right-hand side of the specification. First, the main indicators of macroeconomic policy are the government consumption to GDP, inflation and trade openness (measured by the sum of export and import to GDP). This is due to the lack of tax revenue data for most countries during the period 1976-2004. To construct the policy variable, a standard growth equation, excluding the foreign aid term, is estimated using the pooled fixed effect estimator. The policy variable is constructed as:

$$Policy = 0.48 + 1.74 \times Government\ Consumption - 4.47 \times Inflation + 6.87 \times Openness.$$

Second, political and institutional variables are chosen with an eye to obtain as many time series observations as possible. The existing literature has also focused on subjective measures of political and institutional risk like the International Country Risk Guide. But this dataset does not provide sufficient time series going back as early as the 1970s for most of the countries. As such, to measure political and institutional quality, the contract-intensive money (CIM) ratio by Clague et al. (1999) was constructed. In line with the literature, the state of financial development is proxied by one year lag of M2 to GDP.

The long-run growth relationship is given by:

$$\begin{aligned} \ln y_{it} &= \theta_{0i} + \theta_{1i} \ln CIM_{it} + \theta_{2i} \ln \left(\frac{M2}{GDP} \right)_{it-1} + \theta_{3i} Policy_{it} + \theta_{4i} \left(\frac{Aid}{GDP} \right)_{it} \\ &\quad + \theta_{5i} (Aid \times Policy)_{it} + \theta_{ji} X_{jit} + u_{it}, \\ i &= 1, 2, ..., N; \ t = 1, 2, ..., T \end{aligned} \tag{1}$$

where y_{it} is the level of real GDP per capita, $\ln CIM_{it}$ is the proxy for political and institutional quality, $\ln \left(\frac{M2}{GDP}\right)_{it-1}$ is the proxy for financial development, $Policy_{it}$, $\left(\frac{Aid}{GDP}\right)_{it}$ and $(Aid \times Policy)_{it}$ represent the policy, aid, and interactive term between aid and policy. The matrix X_{jit} consists of a set of other variables including foreign direct investment/GDP and debt serviceability/GNI.

Most empirical studies exploring the nexus between aid and growth suggest that θ_{4i} could be positive or negligible. For a discussion on this aspect of the empirical debate, see Dalgaard et al. (2000) and Boone (1994, 1996). In a related study, Singh (1985) suggests the impact of aid could be negligible due to state intervention in the economy. Pallage and Robe (2001) also show that the volatile nature of foreign aid could affect developing countries' income, and subsequently, lead to negative growth. Whereas, $\theta_{5i} > 0$ as shown by Burnside and Dollar (2000). Recent evidence by Easterly et al. (2004) show that this finding is not robust to the addition of time series observations and countries. Since the variables CIM and $\frac{M2}{GDP}$ are proxies for institutional quality and financial development, intuitively, one would expect $\theta_{1i} > 0$ and $\theta_{2i} > 0$ respectively.

For expositional purposes, let us assume that these variables are $I(1)$ and cointegrated. This means u_{it} is an $I(0)$ process for all i and is independently distributed across t. They are also assumed to be distributed independently of the regressors. Since this is a form of error correction model, the lag length is chosen based on Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) with a maximum lag length of one. This is to preserve sufficient degrees of freedom so as to avoid small sample bias. The autoregressive distributed lag (ARDL) model is:

$$\begin{aligned}\ln y_{it} &= \mu_{it} + \delta_{10i}\ln CIM_{it} + \delta_{11i}\ln CIM_{it-1} + \delta_{20i}\ln\left(\frac{M2}{GDP}\right)_{it-1} + \delta_{21i}\ln\left(\frac{M2}{GDP}\right)_{it-2} \\ &\quad \delta_{30i}Policy_{it} + \delta_{31i}Policy_{it-1} + \delta_{40i}\left(\frac{Aid}{GDP}\right)_{it} + \delta_{41i}\left(\frac{Aid}{GDP}\right)_{it-1} + \\ &\quad \delta_{50i}(Aid \times Policy)_{it} + \delta_{51i}(Aid \times Policy)_{it-1} + \delta_{j0i}X_{jit} + \delta_{j1i}X_{jit-1} + \lambda_i y_{it} + \varepsilon_{it}.\end{aligned} \tag{2}$$

The error correction equilibrium representation is derived as:

$$\Delta \ln y_{it} = \phi_i[y_{it-1} - \theta_{0i} - \theta_{1i}CIM_{it} - \theta_{2i}\left(\frac{M2}{GDP}\right)_{it-1} - \theta_{3i}Policy_{it} - \theta_{4i}\left(\frac{Aid}{GDP}\right)_{it} \quad (3)$$
$$-\theta_{5i}(Aid \times Policy)_{it} - \theta_{ji}X_{jit}] - \delta_{11i}\Delta CIM_{it} - \delta_{21i}\Delta\left(\frac{M2}{GDP}\right)_{it-1}$$
$$-\delta_{31i}\Delta Policy_{it} - \delta_{41i}\Delta\left(\frac{Aid}{GDP}\right)_{it} - \delta_{51i}\Delta(Aid \times Policy)_{it} - \delta_{j1i}\Delta X_{jit} + \varepsilon_{it},$$

where $\theta_{0i} = \frac{\mu_{it}}{1-\lambda_i}$, $\theta_{1i} = \frac{\delta_{10i}+\delta_{11i}}{1-\lambda_i}$, $\theta_{2i} = \frac{\delta_{20i}+\delta_{21i}}{1-\lambda_i}$, $\theta_{3i} = \frac{\delta_{30i}+\delta_{31i}}{1-\lambda_i}$, $\theta_{4i} = \frac{\delta_{40i}+\delta_{41i}}{1-\lambda_i}$, $\theta_{5i} = \frac{\delta_{50i}+\delta_{51i}}{1-\lambda_i}$, $\theta j = \frac{\delta_{j0i}+\delta_{j1i}}{1-\lambda_i}$and $\phi_i = 1 - \lambda_i$.

Equation (3) is estimated using the maximum likelihood estimation procedure described in Pesaran et al. (1999). The estimates of the coefficients are obtained using the Newton-Raphson algorithm, which uses both first and second derivatives of the log-likelihood function. The mean group estimates have been used as initial estimates for the long-run parameters of the pooled maximum likelihood estimation. For long-run equilibrium to exist and convergence to take place, the estimated error correction adjustment term in equation (3), ϕ_i has to be negative. This estimation procedure allows one to choose between two type of lag specifications. In general, a restricted ADRL model can be estimated by imposing a fixed lag length for all groups. However, this approach might impose too much restriction on the lag structure. Besides the fixed lag length option, this procedure also allows one to choose lag structures based on two common selection criteria, namely the Akaike Information Criterion (AIC) and the Schwartz Bayesian Criterion (SBC). The maximum lag order can be specified. In what follows, the results presented are based on lag length chosen by both AIC and SBC with a maximum lag length of one. In view of the total dimension $N \times T = 551$ of the panel, this is chosen to avoid small sample biases which could arise from the estimation of a large number of country specific parameters.

Although the standard practice in the applied PMG literature is to assume that all long-run coefficients are the same across groups, a subset of the long-run coefficients are allowed to be the same while the rest differs. Related to this, albeit the fact that the PMG estimator is consistent for large N and T, the problem of bias estimate associated with the lagged dependent variable exists when T is small. Under such circumstances, the estimates of ϕ_i will be downward bias. Increasing the cross-sectional dimension would not solve the problem as the direction of the bias are in the same direction. Thus, given the limited number of time series observations of $T = 29$, the exercise of relaxing the long-run homogeneity assumption on certain coefficient is left for future research with the availability of more data observations. Also, given T is relatively small, the MG estimates are not reported as they may suffer from small T bias stemming from the lagged dependent variable problem.

3 Results

3.1 Data

The dataset comprises of 19 countries in Sub-Saharan, Middle and North-Eastern Africa and spans the period 1976 - 2004. The description on sources of data can be found in Appendix A at the back of the paper. The primary source of data includes the World Development Indicator and International Financial Statistics. Some missing gaps were interpolated so as to attain a balanced panel.[3]

The long-run relationship between growth and aid (equation (1)) cannot be consistently estimated if the variables have unit root problems. Furthermore, it is also important to check that a cointegrating relationship exists. In what follows, the statistical properties of variables are investigated before proceeding with the estimation.

3.2 Unit Root and Cointegration Tests

To test for stationarity of the variables in the panel dataset, two panel unit root test procedures that are commonly used in the PMG literature are applied. These are the Levin and

[3]This is attained using the extrapolation command in STATA 9 SE.

Lin (1992) and the Im et al. (2003) procedures.[4] The Levin and Lin procedure tests the hypothesis that all cross-sectional groups are stationary against the hypothesis that they are all non-stationary. This procedure is a more restrictive because it pools the autoregressive parameter across groups. On the other hand, the Im et al. (2003) procedure allows for residual serial correlation and heterogeneous dynamics and error variances across groups. In this case, some variables for certain group may be stationary. As such, the Im et al. procedure is better.

Table (1) reports the results based on a common lag length of one. Across the two tests, the results from the Im et al. (2003) are more sensible given that most of the variables are I(1) in levels. Inflation and the aid-policy term turn out to be I(0) in levels. The order of integration of aid-policy is stationary by construction since it is a linear combination of two I(1) variables in levels, that is, the aid/GDP and policy variables. The rest of the variables are I(0) in difference, and as such, the variables in the dataset may sensibly constitute a stationary cointegrating relation, with the exception of debt serviceability and FDI/GDP.

The Pedroni's (1999) procedure is adopted to test for the presence of a long-run cointegrating relation amongst variables in each specifications. This is a residual based test designed to test for the degree of heterogeneity within groups with respect to the intercepts, error structures and the homogeneous cointegrating relationship. The null hypothesis is the absence of cointegration. Although there are seven key statistics available from this test, two broad statistics are commonly reported in practice: (i) pooling within groups (panel) and (ii) pooling between groups (group mean). The results for these tests are reported for each specifications, and they can be found at the bottom rows of Tables (2) to (4).

[4] These tests were performed using routines available in STATA 9 SE.

3.3 Estimating Growth, Aid and Policy

3.3.1 All countries

To investigate the significance of foreign aid and 'good' policy on growth, a number of specifications are estimated. The first group comprises of specification with aid, policy and aid-policy interaction terms following Burnside and Dollar (2000). Aid squared and policy squared terms are also included to test for the existence of a polynomial relationship between aid and growth (see, for example, Hansen and Tarp, 2001). In particular, the focus is on the presence of diminishing marginal returns to aid (see Hadjimichael et al., 1995 for discussion). The second set of results follows specifications from the first group. But the countries are classified in terms of being "poor" and "rich" based on an arbitrarily chosen level of real GDP per capita (based on US dollars term in 2000) of US$500. Since the policy variable is, to some extent, an aggregate policy index, the third set of specifications include components of the policy variables.[5]

Table (2) presents results obtained from the basic specifications in the literature. Across specifications, the results reveal that aid/GDP impact is found to be usually negative on the growth of economies in the long run. This reinforces the general conclusion from Singh (1985) and Pallage and Robe (2001). Being an ARDL model, the result may be sensitive to the choice of lag length. In what follows, a maximum lag length of one for the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion is imposed to obtain optimal lag length for various variables. But, the sign and significance of this variable is robust to the choice of the lag length selection criterion, except for columns 5 and 6 of Table (2), which include squared terms of aid/GDP and policy.

For a certain number of countries, the hypothesis on the absence of long-run equilibrium cannot be rejected. In 16 out of 19 countries, the speeds of adjustment are well-behaved. The estimated ϕ_i for Algeria is -0.264 while that of Ghana is estimated to be -0.098. A check

[5] Specifications which include debt serviceability and foreign direct investment were estimated. The signs of the estimated coefficients are wrongly signed, and thus counter-intuitive. Furthermore, as suggested by the panel unit root tests, they are I(0) in levels.

on the diagnostic statistics shows the presence of serial correlation in 5 out of 19 countries, 4 out of 19 countries suffer from misspecification of functional form, and 3 countries have non-normal errors, and heteroskedasticity problems exist for 5 out of 19 countries.[6]

On the other hand, the impact of good policy is found to be robust and the magnitude is robust across specifications and lag lengths. Using columns 2 and 4 of Table (2), since the coefficient of aid/GDP and policy are semi-elasticities, the estimated effect of aid and policy on growth are around -0.20% to -0.26% and around 0.06% respectively. Another noteworthy result is that the interaction term between aid and policy is found to be small and not significant. Besides these variables, the quality of institution, measured by the CIM, and the level of financial development are estimated to have positive effect on growth.

The Hausman test statistic, with the null hypothesis of no difference between the MG and the PMG estimators, cannot be rejected at the 5% significance for the first two columns of the Table (2). With the imposition of long run homogeneity, the objective of this test is to ensure that the pooled estimates are not biased. However, for the rest of the specifications, the Hausman test statistic is indeterminate as the difference between the variance-covariance matrices of the MG and PMG estimators is not positive definite.

Results from columns 5 and 6 in Table (2) are interesting. While the coefficients of aid/GDP and policy remains similar in magnitude and statistically significant, the squared terms of aid and policy are found to be small. Nonetheless, this suggests that the presence of a quadratic relationship between aid and growth and substantiates the hypothesis of diminishing return to aid. Using column 6, the total effect of aid on growth can be computed as $1.849 - 0.006\overline{policy} - 0.002 = 1.844$, where $\overline{policy}$ is the mean of the policy variable. This specification also allows one to compute the optimal amount of aid, measured in terms of percentage of GDP, is around 12.67%. This is low compared to the mean of aid/GDP in the entire sample, 7.0% of GDP.

The results indicate that the PMG results are robust to the two ARDL specifications

[6] These statistics are not reported, but available upon request.

considered. Overall the estimates suggest that the average long-run impact of aid is negative rather than positive. The aid and policy interaction term is estimated to be small and insignificant for most ARDL specifications. The average adjustment coefficient ϕ_i is between -0.15 to -0.24. On average, this translates to a half-life of between 2.9 to 4.6 years for a shock to dissipate amongst the countries.

3.3.2 "Poor" and "rich" countries

The next step in the analysis separates the countries into two sub-groups: the "poor" and the "rich". To do so, an arbitrary level of real GDP per capita of US$500 at 2000 US dollars term at the beginning of the time period 1976 was chosen. The countries with real GDP per capita less than US$500 are Gambia, Ghana, Kenya, Madagascar, Nigeria, Niger, Senegal, Sierra Leone, Sudan, and Togo. The countries with real GDP per capita greater than US$500 are Algeria, Botswana, Cote d'Ivoire, Egypt, Gabon, Morocco, Swaziland, Turkey, and Zimbabwe. There are various reasons for doing so. First, the "richer" countries may have already benefitted from access to international capital markets, and thus, enjoyed a higher level of economic well-being. As such, foreign aid might have a counter-productive effect on the growth experience. Second, it also serves as a sensitivity check on the results discussed in the previous section. Finally, the income gap between the "rich" and "poor" country might be so high that it might have biased the estimates.

Table (3) shows the results of PMG estimates following specifications in Table (2) with countries classified by sub-groups. There are several noteworthy findings. First and foremost, the convergence term ϕ_i for the richer countries are slower than that of the poorer countries. As a country gets richer, the speed of convergence towards the long-run steady state will be slower. This feature is evident across specifications. Second, the policy variable continues to contribute positively to growth irrespective of the income level. The effect of foreign aid on growth is mixed. The coefficients of aid/GDP have opposite signs in columns 3 and 4. This further supports the hypothesis that allocation of aid to the "richer" countries, in itself, may have counter-productive effect. Nevertheless, the estimated magnitude is small. The PMG estimates of the aid and policy interaction term is found to be small. Third, the level of financial development turns out to be a key determinant of growth. However, the quality of institutions, as proxied by the CIM variable, is irrelevant. Thus far, the broad results are quite consistent with that in the previous section.

Besides the main findings, a quadratic relationship between aid and growth is found to exist amongst the poorer countries. This supports the hypothesis that dropping the richer countries from the main sample might have removed some of the outliers in the sample. With reference to column 5 of Table (3), the aid and policy interaction is now significant as compared to that of Table (2). However, the sign of this coefficient is negative which suggests the allocation of foreign aid to the poorer countries based on 'good' policy is counter-productive. Similarly, the optimal amount of aid can be computed as $0.03 - 0.011\overline{policy}^{poor} - 0.001aid$. This yields an optimal aid allocation of 20.8% of GDP compared to the mean of aid/GDP amongst these countries which amount to around 3.3% of GDP. Coupled with a faster speed of adjustment, this suggests a jump-start in aid flow to the poorer countries may propel these economies on a faster trajectory towards their long-run steady state growth.

The PMG estimates of the long-run determinant of growth for the richer countries are not significant. This suggests that the growth experiences of the 'better off' African economies may be so diverse that it is difficult to pin down a homogeneous long-run equilibrium.

3.3.3 Individual policy variables

The policy variable is a linear restriction on a set of macroeconomic policy variables that are commonly used in country surveillance. The inclusion of such an aggregated variable might have imposed an unnecessary restriction. As such, this does not allow one to determine the potential channels in which foreign aid interacts with the economy. Table (4) presents PMG estimates for specifications with the standard control variables of institutional quality and financial development. The ARDL specification is chosen using the SBC. The main difference lies in the type of macroeconomic indicator used: government consumption, CPI, and openness to trade.

Several general conclusions can be drawn from Table (4). First, the average speed of adjustment for the countries $\overline{\phi}$ remains robust around -0.13 to -0.23. This translates to a fairly slow rate of convergence with half-lives ranging between 3 to 5 years on average. Second, institutional quality remains a key driver for growth. The estimates of the long-run coefficient of CIM is positive and is robust when controlled by various individual policy indicators. Third, the phase of financial development is crucial to the explanation of growth. Similar to institutional quality, the long-run impact of financial development is positive and significant.

On the effects of aid and individual policies, the results are illuminating. As shown in Column 1 of Table (4), the long run impact of foreign aid on growth estimated at 1.5% is large. In comparison to column 5 of Table (3), this is 50 times bigger. The interaction between aid and government consumption is found to be negative, which suggests that aid effectiveness could potentially be counter-productive. This is so given that both variables will contribute to growth. The estimates on the long-run coefficient of government consumption is found to be negative. Intuitively, the sign of this coefficient should be positive. Due to the lack of fiscal revenue data in this setting, the sign of this coefficient might be ambiguous. Column 2 shows a specification whereby CPI was included as the policy variable. As expected, high inflation rate will lower growth rate. However, the sign on the coefficient of aid is found to be negative but not significant. The interaction between aid and CPI is found to be positive.

When openness to trade was used as the policy variable, Column 3 of Table (4) shows that aid effectiveness is positive. Similar to specification with government consumption, the estimated long-run coefficient of aid is around 1.5%. The focus of trade liberalisation may be a viable strategy for growth. The aid-trade interaction, though significant, is estimated to be close to zero.

The main result that can be derived so far is that aid effectiveness is sensitive to the choice of policy variables. And, the allocation of aid based on a particular macroeconomic indicator is potentially misleading.

4 Some Simulations

Though the estimated elasticities and statistical significance of the key variables may help in the decision making process on the allocation of aid, it does not allow one to analyze the interaction between aid and growth over time. Instead, this section attempts to examine the impact of a persistent shock to foreign aid for a group of selected countries by conducting a simple policy experiment. This group comprises of the poorer countries in the dataset, namely Ghana (Gha), Kenya (Ken), Madagascar (Mad), Nigeria (Nig) and Niger (Nir). The foreign aid variable of each of these countries is perturbed by one standard deviation computed based on the historical distribution of the foreign aid variable in each of these countries. This shock is assumed to be persistent and decay exponentially by a factor of 0.9 every year. Since the shock dies out asymptotically, the impact of growth converges back to zero over time. The evolution of aid on growth is governed by:

$$\begin{aligned} \Delta \ln y_{it} &= \phi_i \ln y_{it-1} + \beta aid/GDP_{it} + \lambda_i \Delta \ln y_{it-1} + \gamma_i \Delta aid/GDP_{it} + u_{it} \qquad (4) \\ &= \phi_i(\ln y_{it-1} - \widetilde{\ln y}) + \beta aid/GDP_{it} + \lambda_i \Delta \ln y_{it-1} + \gamma_i \Delta aid/GDP_{it} + u_{it}, \\ i &= \text{Gha, Ken, Mad, Nig, and Nir.} \end{aligned}$$

where $\widetilde{\ln y}$ is the long-run equilibrium, and ϕ_i, λ_i and γ_i are the short-run adjustment terms. The difference between the lagged natural logarithm level of real GDP per capita and the long run equilibrium level is $(\ln y_{it-1} - \widetilde{\ln y})$. The estimated parameter ϕ_i measures the speed of convergence to of country i. The differences in the speed of adjustment ϕ_i and heterogeneous short-run dynamics (λ_i and γ_i) are responsible for the heterogeneous dynamic profiles to an increase in aid.

Figure (1) presents the dynamic responses of these countries to a persistent positive aid shock. In the Figure, there are two panels. The top panel shows the simulation conducted based on estimated coefficients of the linear specification from column 4 of Table (2), while the bottom panel shows that of the coefficients from the quadratic specification from column 6 of the same table.

In general, the conclusion depends on the specifications of the growth regressions. Besides this, the speed of convergence for individual countries and its individual short-run adjustment terms play a critical role in the short-run adjustment process. For the case of the linear specification, a positive shock to foreign aid generally has positive impact on growth in the short run. However, this is not the case for Nigeria. In the short run, aid contributes positively to the growth of Ghana, Kenya and Niger. Meanwhile, the impact of aid on growth is the largest for the Madagascar. Overall, the results suggest that increase in foreign aid contributes to growth in four out of the five poorer countries.

The bottom panel of Figure (1) reveals substantial difference in the dynamic responses of the same group of countries when the estimated parameters are based on the quadratic specification. Generally, a positive increase in foreign aid has a negative impact on growth over time. This outcome is due to the estimated negative coefficient on the short-run adjustment associated with aid/GDP. The exception is Niger which experiences negative growth in the short run, but positive growth in the long run. This finding reinforces the role of diminishing marginal return to aid (see Section 3.3.1). Again, this is due to the interaction between the speed of adjustment and the heterogeneous short-run adjustment terms.

5 Conclusion

The question on the effectiveness of aid will remain a highly debatable issue. This paper has explored the aid and growth nexus for a panel of 19 African countries over the period 1976 - 2004 by the novel application of the pooled mean group estimation procedure. This technique is suitable for panel dataset with large time dimension in view of potential bias estimates with the inclusion of lagged dependent variable commonly found in the empirical growth literature. Having determined a homogeneous long-run relation amongst variables of interest, the estimates of individual speed of adjustment and short-run adjustment terms provide richer transitional dynamics to the analysis of countries with different characteristics in the short run.

The general conclusion depends on the specifications of the growth regression. In the linear specification, aid reduces the growth rate of the economy in the long run. Whereas, in the specification with quadratic terms in aid and policy, the evidence supports the hypothesis of diminishing marginal returns to aid. With that, there is a positive critical level of growth that could optimal for growth. In both cases, the aid and policy interaction term is found to be insignificant and small. This further substantiates the conclusion drawn in Hansen and Tarp (2001) that it is "premature" to rely on policy indexes in the decision on allocation of aid. When macroeconomic indicators are considered one at a time, the interaction of aid with the respective indicator remains small and are often of the wrong signs. Nonetheless, quality of institution, level of financial development and policy variables remain key determinants of growth.

While this conclusion may suggest that empirical evidence about aid effectiveness remain mixed, the policy simulations conducted based on PMG estimates reveal that aid effectiveness depend on the specification of the growth regression. In the linear specification, aid generally has a positive effect on growth during the transition period. On the other hand, aid has negative implication on growth when quadratic specifications are considered. Given that the PMG estimates contains heterogeneous speed of convergence and short-run adjustment terms, the focus on the signs of long-run coefficients of aid on growth in itself may be misleading.

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Appendix A: Description of variables and their source

Variable	**Explanation and source**
real GDP per capita in log ($rgdppc$)	GDP per capita based on constant local currency unit. Source: World Development Indicator, April 2006.
Government Consumption/GDP in log ($govtgdp$)	General government final consumption expenditure (formerly general government consumption). Source: World Development Indicator, April 2006.
Inflation (CPI)	Consumer price index changes. Source: International Financial Statistics.
Trade/GDP in log ($TRADE/GDP$)	The sum of export and import to nominal GDP. Source: World Development Indicator, April 2006.
Aid/GDP (Aid/GDP)	Original series is Aid/GNI obtained from World Development Indicator. The variables is obtained by using corresponding series of GNI and GDP. Source: World Development Indicator, April 2006.
M2/GDP in log ($m2gdp$)	Money and quasi-money. Source: International Financial Statistics.
CIM in log (CIM)	Computed based on M2 and currency held outside banks following Clague et al. (1999). Source: International Financial Statistics.
Debt serviceability/GNI in log ($DEBTSVC/GNI$)	Debt serviceability as a proportion of GNI. Source: World Development Indicator, April 2006.
Foreign direct investment/GDP (FDI/GDP)	Foreign direct investment as a proportion of GDP. Source: World Development Indicator, April, 2006.

Table 1: Panel unit root tests

	Levin-Lin (1992)		**Im et al. (2003)**	
Variables	**Level**	**Difference**	**Level**	**Difference**
$\ln rgdppc$	I(0)	I(0)	I(1)	I(0)
$\ln m2gdp$	I(1)	I(0)	I(1)	I(0)
$\ln CIM$	I(0)	I(0)	I(1)	I(0)
CPI	I(0)	I(0)	I(0)	I(0)
$Trade/GDP$	I(0)	I(0)	I(1)	I(0)
Aid/GDP	I(0)	I(0)	I(1)	I(0)
FDI/GDP	I(0)	I(0)	I(0)	I(0)
$GOVT/DGDP$	I(1)	I(0)	I(1)	I(0)
$\ln DEBTSVC/GNI$	I(0)	I(0)	I(0)	I(0)
$Policy$	I(1)	I(0)	I(1)	I(0)
$Aid \times Policy$	I(1)	I(0)	I(0)	I(0)

Table 2: Baseline estimates, lag length chosen based on AIC and SBC (max lag = 1)

	1	2	3	4	5	6
Dependent variable: log $rgdppc$	AIC	SBC	AIC	SBC	AIC	SBC
Convergence coefficients $\frac{1}{N}\sum_{i=1}^{N}\phi_i$	-0.148	-0.236	-0.233	-0.234	-0.207	-0.230
	(3.98)***	(3.32)***	(3.27)***	(3.28)***	(2.94)***	(2.81)***
Long run coefficients						
$\log CIM$	0.057	0.055	0.059	0.059	0.076	0.114
	(1.73)*	(1.76)*	(1.74)*	(1.73)*	(2.20)**	(3.15)**
$\log M2/GDP(lagged)$	0.076	0.076	0.071	0.070	0.075	0.100
	(6.29)***	(6.72)***	(5.96)***	(5.91)***	(5.06)***	(7.26)***
$Policy$	0.057	0.057	0.057	0.057	0.071	0.088
	(8.47)***	(10.48)***	(7.39)***	(7.34)***	(6.38)***	(7.22)***
Aid/GDP	-0.194	-0.201	-0.265	-0.258	0.824	1.849
	(1.28)	(2.18)**	(2.04)**	(2.02)**	(2.93)**	(6.13)***
$Aid \times Policy$			0.000	0.000	0.000	-0.006
			(0.37)	(0.64)	(0.05)	(6.16)***
$(Aid/GDP)^2$					0.000	-0.001
					(5.36)***	(6.18)***
$Policy^2$					-0.006	-0.006
					(1.81)*	(1.88)*
Diagnostic statistic						
Hausman	8.73	9.26	n.a.	n.a.	n.a.	n.a.
p-value	0.07	0.05				
Cointegration Test						
Panel		18.81		11.42		11.91
Group-mean		13.19		13.40		13.83

Note: All equations include a constant country-specific term. t-statistics are in parentheses.
*** significant at the 1% level; ** at the 5% level; * at the 10% level.

Table 3: Baseline estimates by sub-groups of countries, lag length chosen based on SBC (max lag = 1)

	1	2	3	4	5	6
Dependent variable: log $rgdppc$	$< US\$500$	$> US\$500$	$< US\$500$	$> US\$500$	$< US\$500$	$> US\$500$
Convergence coefficients $\frac{1}{N}\sum_{i=1}^{N}\phi_i$	-0.305	-0.180	-0.237	-0.161	-0.311	-0.016
	(2.42)**	(2.80)**	(1.85)*	(2.71)**	(2.06)**	(1.19)
Long run coefficients						
$\log CIM$	-0.064	0.075	0.039	0.058	0.066	0.323
	(1.41)	(2.21)**	(0.70)	(1.30)	(1.82)*	(1.12)
$\log M2/GDP(lagged)$	0.062	0.073	0.119	0.053	-0.127	0.243
	(2.82)**	(5.46)***	(6.60)**	(3.39)**	(7.89)***	(1.17)
$Policy$	0.052	0.048	0.117	0.044	0.133	0.020
	(9.10)***	(5.75)***	(7.19)**	(4.53)**	(8.28)***	(0.34)
Aid/GDP	0.000	-0.006	0.006	-0.006	0.030	-0.687
	(0.16)	(2.14)**	(4.17)**	(1.65)*	(7.74)***	(1.26)
$Aid \times Policy$			-0.001	0.010	-0.011	0.264
			(7.06)**	(3.10)**	(8.25)***	(1.10)
$(Aid/GDP)^2$					-0.001	1.025
					(6.84)***	(1.15)
$Policy^2$					0.008	-0.046
					(2.31)**	(0.79)
Diagnostic statistic						
Hausman	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
p-value						
Cointegration Test						
Panel	13.33	11.87	13.54	10.86	13.90	11.53
Group-mean	10.42	9.92	10.41	10.47	10.76	10.31

Note: All equations include a constant country-specific term. t-statistics are in parentheses.
*** significant at the 1% level; ** at the 5% level; * at the 10% level.

Table 4: Estimating growth and aid using various policy variables, lag length chosen based on SBC (max lag = 1)

Dependent variable: log $rgdppc$	1	2	3
Convergence coefficients $\frac{1}{N}\sum_{i=1}^{N}\phi_i$	-0.126	-0.232	-0.198
	(3.98)***	(2.92)***	(2.87)***
Long run coefficients			
$\log CIM$	0.262	0.151	0.132
	(3.98)***	(3.91)***	(3.58)***
$\log M2/GDP(lagged)$	0.106	0.101	0.093
	(5.36)***	(8.36)***	(6.44)***
$\log GOVT/GDP$	-0.051		
	(1.64)		
CPI		-0.189	
		(3.89)***	
$\log TRADE/GDP$			0.204
			(7.53)***
Aid/GDP	1.541	-0.043	1.546
	(4.02)***	(0.57)	(6.11)***
$Aid \times \log GOVT/GDP$	-0.001		
	(4.25)***		
$Aid \times CPI$		0.582	
		(2.37)**	
$Aid \times \log TRADE/GDP$			0.000
			(7.45)***
Diagnostic statistic			
Hausman	n.a.	24.68	n.a.
p-value		0.00	
Cointegration Test			
Panel	11.35	11.12	11.86
Group-mean	13.48	12.98	14.00

Note: All equations include a constant country-specific term. t-statistics are in parentheses. *** significant at the 1% level; ** at the 5% level; * at the 10% level.

Figure 1: Impulse responses of selected countries to a persistent aid shock