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The Allocation of Volatile Aid and Economic Growth: Evidence and a Suggestive Theory‡

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Abstract

We present evidence on the effects of aid transfers and their degree of volatility on economic growth and show that these effects can be categorised in relation to the allocation of foreign aid between productive and non-productive purposes. Using a stochastic endogenous growth model, we provide a theoretical rationalisation for our empirical evidence. Both the empirical and the theoretical analyses generate a pertinent conclusion: situations in which aid actually inhibits the recipient's growth rate may appear if and only if aid is volatile. As a result, we conclude that it is only in conjunction with the presence of aid variability that aid allocation decisions determine whether aid hurts or promotes trend growth.

JEL Classification: F35; O41; O47

Keywords: Foreign aid; Growth

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1 Introduction

Recent years have witnessed a resurgence on the interest of how foreign aid can affect economic growth – an issue that has preoccupied both academic economists and policy makers. This renewed interest has been translated in a substantial number of both theoretical and empirical analyses, seeking to promote our understanding of the conditions under which aid could be effective (in terms of long-run macroeconomic performance) for recipient economies.[1]

Empirically, aid effectiveness has been shown to depend crucially upon the characteristics of recipient countries – most notably on the degree of political and civil liberties (e.g., Svensson 1999), on the quality of policy making and institutions (e.g., Burnside and Dollar 2000; Collier and Dollar 2002), and on climate-related factors (e.g., Dalgaard *et al.* 2004). At the theoretical level, authors have only recently began to analyse the long-term effects of foreign aid in the context of endogenous growth models. Obstfeld (1999) finds that foreign aid given in the form of lump-sum transfers (i.e., non-productive aid) does not affect steady-state growth but increases the speed of convergence towards the balanced-growth path. Similar results, concerning this particular form of aid, are reached by Chatterjee *et al.* (2003). They argue, however, that when aid is tied to public investment projects (i.e., productive aid) then it is likely to stimulate steady-state growth. In a similar vein, Kalaitzidakis and Kalyvitis (2007) argue that foreign aid can boost the recipient's growth rate if it is used to co-finance the formation of public capital. Finally, by including elastic labour supply Chatterjee and Turnovsky (2007) find that non-productive aid has adverse effects on economic growth as it distorts the labor-leisure choice in such a way that induces agents to reduce their work effort.[2]

All the above analyses share a common feature – mainly, their silence on the issue of variability in foreign aid transfers and the implications that may arise from it, despite the fact that recent empirical studies (e.g., Pallage and Robe 2001; Bulíř and Hamann 2003, 2006)

[1] See World Bank (1998) and Easterly (2003) for an overview of the issue.

[2] Other theoretical analyses link foreign aid with the macroeconomic environment without focusing on the issue of long-run growth. Boone (1996) argues that, depending on the prevailing political regime, foreign aid can induce the government to either reduce domestic taxation or increase lump-sum transfers. Asiedu and Villamil (2002) show how different kinds of foreign assistance may alleviate the underinvestment problem that arises when the enforcement of debt contracts in international financial markets is imperfect.

have documented that aid is highly volatile.[3] This volatility may be an additional and important factor determining the success of foreign aid in improving the growth rates of recipient economies and, consequently, increasing the prospect of higher levels of development.[4] Indeed, this may be a particularly significant consideration, in light of recent stochastic, dynamic general equilibrium models (e.g., Blackburn and Galindev 2003) and empirical analyses (e.g., Ramey and Ramey 1995), that show how and for what reasons can different kinds of variability affect long-run growth.

The present analysis is concerned with highlighting the additional repercussions emerging for the foreign aid-economic growth nexus when variability in foreign assistance is taken under consideration – an issue that, so far, has eluded the attention of researchers. The novelty of our approach on examining the growth effects of foreign aid lies on explicitly taking account of both the volatility on the provision of foreign financial assistance and on considering the allocation of aid transfers between productive and non-productive uses.

We begin with an empirical analysis in which we utilise a panel that covers up to 66 aid-recipient countries over the sample period from 1973 to 1998 and consider one eight-year and two nine-year period time intervals that correspond to three different decades. Since our aim is to distinguish the growth effects of the productive and unproductive components of aid and of their respective volatilities, we obtain their proxies by adopting the classification methodology of Clemens *et al.* (2004). By considering the heterogeneity of aid, both at its levels and at its degree of instability, we find that aid disbursements used for productive purposes have a positive effect on growth, while unproductive use of them decreases growth. In contrast, the volatility of productive aid is found to hurt growth, while the variability of unproductive aid is associated with higher growth. These results are found to be robust to a wide range of sensitivity tests, including different estimation techniques and period averaging.

The next step is to provide a possible theoretical justification for our empirical results. The theoretical framework we employ is described by an analytically-tractable, stochastic growth model in which the accumulation of – both private and public – capital provides the underlying source of endogenous, sustainable growth (e.g., Futagami *et al.* 1993). In this

[3] For instance, Pallage and Robe (2001) report an average volatility of aid inflows of about 25% in African recipients and 29.5% in non-African recipients.

[4] Pallage and Robe (2001) make this clear with their statement that "…if one is interested in the welfare or the growth of recipient countries, one cannot not be interested in the pattern of disbursements."

environment, the government receives an inflow of foreign transfers which then allocates between productive (i.e., formation of public capital) and non-productive (i.e., lump-sum income transfers) uses. However, these transfers are not stable through time. Instead, they are characterised by some degree of variability. The dynamic process for private capital depends on the resources the individuals devote for this purpose, while that of public capital may depend on both domestic financing (through tax revenues) and on external financing (through aid receipts). As it turns out, our model can produce a theoretical rationale for our empirical results. As it will become clear in the main text, the optimal response of the private sector's capital investment plays a crucial role in generating these effects.

Moreover, both the empirical analysis and the theoretical model generate an additional but even more important result that introduces a new dimension on the interactions between aid receipts and growth performance: The possibility that foreign aid inhibits the growth rate of the recipient emerges only when aid disbursements are volatile. Consequently, the presence of aid variability is the key factor in rendering the allocation of foreign aid among different uses as an important determinant of its effectiveness.

The rest of the paper is organised as follows: In Section 2 we discuss the empirical methodology and describe the data. In section 3 we present our basic results and conduct the robustness testing. Section 4 lays out the theoretical framework and derives the results concerning the impact of foreign aid, and its volatility, on the rate of output growth. Section 5 concludes.

2 Methodology and Data

Our aim is to examine the growth effects of aid transfers as a function of the behaviour of both the donor and recipient countries. We do this by jointly considering the allocation of aid flows by recipients into productive and unproductive uses and the time profile of their respective distribution by donors. Although the notions that different types of aid may have different effects on growth and that the volatility of aid may affect growth are by no means novel, they have only been examined independently of each other.[5] In this and the next

[5] The aid disaggregation issue has been empirically studied, among others, by Clemens *et al.* (2004), Gomanee *et al.* (2005), and Reddy and Minoiu (2006), while aid volatility has been examined by Lensink and Morrissey (2000), Pallage and Robe (2001), Bulíř and Hamann (2003, 2006), Fielding and Mavrotas (2005), and Prati and Tressel (2006).

section we offer an empirical investigation that combines these two strands of the literature, which is then followed by a suggestive theoretical explanatory analysis of the findings.

2.1 Methodology

To test the effect of aid and its respective volatility on economic growth, first we need to classify the use of aid flows by the recipient government into productive and unproductive. This classification is based on Clemens *et al.* (2004), who disaggregate aid flows into three types – short-impact aid, long-impact aid, and humanitarian aid. According to the authors, all aid is not alike and therefore all types of aid should not be expected to affect economic growth in a similar manner. In other words, there are categories of aid flows that are expected to enhance growth within a short period of time of four to five years (i.e., aid used for infrastructure, industry, trade, services, and budgetary support purposes), others that work with a long time lag (i.e., financing health, education, and social infrastructure programmes), and others that may even have a negative association with growth (i.e., emergency food aid and reconstruction relief during and after natural disasters).

In what amounts to our goal, we do not need to make a distinction between short- and long-impact aid as long as we accommodate the element of time. This means that since both types of aid are expected to have a positive impact on growth, albeit with a different time lag, we jointly consider them as productive and adjust the time period averages of study to nine-year intervals. In this way, we manage to strike a balance between the shorter period appropriate to capture the growth effects of short-impact aid and a longer period which is likely to capture the effects of long-impact aid. In addition, this periodization may be more appropriate in assessing the impact of aid volatility on growth compared to a much shorter interval.[6]

Following Clemens *et al.* (2004) and using the OECD's Creditor Reporting System (CRS), which reports aid commitments by purpose, the Appendix Table A1 describes the classification of aid flows into the categories under consideration. In addition, Table A2 presents the methodology that has been followed in order to obtain estimates of productive and unproductive aid flows. This requires the use of the OECD's Development Assistance

[6] Although we consider the nine-year average specification as our benchmark, we also examine the potentially different effects of productive versus unproductive aid on growth by considering alternative periodization (four-year intervals) and a higher level of disaggregation to short- and long-impact aid.

Committee (DAC) database, which includes data on total ODA (Official Development Assistance) gross disbursements.[7]

We test our main hypothesis by employing the following model specification:

$$g_{it} = a + \beta_P a_{it}^P + \beta_U a_{it}^U + \beta_r \ln r_{it} + \sum_{j=P}^{U} \delta_j V_{it}^j + \sum_{k=1}^{m} \gamma_k X_{k,it} + \sum_{l=1}^{n} \lambda_l D_{l,it} + \varepsilon_{it}, \qquad [1]$$

where g_{it} denotes the average rate of growth of per capita GDP in country i at time t, a_{it}^P represents gross disbursements of productive aid (% of GDP), a_{it}^U is gross disbursements of unproductive aid (% of GDP), r_{it} is gross repayments on aid (% of GDP), and V_{it}^j is a vector of the volatilities of the two types of aid disbursements measured as the standard deviation of the respective aid type within each time interval.[8, 9] $X_{k,it}$ is a vector of variables that have been identified in previous studies to explain a substantial variation in the data. These are the logarithm of initial income, M2-to-GDP as a proxy for the development of the financial system (e.g., Burnside and Dollar 2000), the fertility rate, the fraction of land in the tropics indicating the idiosyncrasy of these locations (e.g., Dalgaard *et al.* 2004; Clemens *et al.* 2004), and the log of initial life expectancy as a proxy for health conditions (e.g., Clemens *et al.* 2004; Rajan and Subramanian 2005). Finally, $D_{l,it}$ are the dummies controlling for regional differences (Sub-Saharan Africa and East Asia). In addition, all regressions account for common deterministic trends by incorporating dummies for the different time periods.

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[7] As made clear in Clemens *et al.* (2004), the reason we construct our productive and unproductive aid proxies by using the CRS disaggregated aid *commitments* instead of the DAC disaggregated aid *disbursements* is the lack of data of the latter database prior to 1990. Our measures imply that the fraction of disbursements in the two aid categories in a given period is equal to the fraction of commitments in each category in that period. This is not an unrealistic assumption as shown in the analysis conducted by Clemens *et al.* (2004).

[8] As shown in Table A2, the identity that determines gross repayments on aid is $\alpha_{it}^{gross} = \alpha_{it}^{net} + r_{it}$. The decision to use in our specification gross aid disbursements and gross aid repayments instead of net aid disbursements, is based on the consideration that aid repayments possibly have a different association with growth than aid disbursements. That is, we prefer to test for it rather than impose it. As in Clemens *et al.* (2004), aid repayments are assumed to have a non-linear effect, justifying the use of the log operator.

[9] The standard deviation of a variable is commonly used as a measure of its volatility. See, among others, Ramey and Ramey (1995) for a study that calculates the volatility of output. The choice to use the standard deviation of each respective type of aid *as a fraction of GDP* instead, say, of aid in absolute terms, or aid per capita, is based on two considerations. First, as stated in Bulíř and Hamann (2006) although the "denominator matters more for the statistical measures of relative volatility than the definition of aid (…), if the objective is to assess the macroeconomic impact of aid, the relevant denominator is the aid-to-GDP ratio." Second, for consistency, since other studies that deal with the volatility of aid utilize its measurement through the aid-to-GDP ratio (i.e., Lensink and Morrissey 2000; Fielding and Mavrotas 2005; Prati and Tressel 2006).

A positive value of β_P and a negative value of β_U would indicate the importance of the disaggregation of aid flows when examining the aid-growth relationship. It would also provide a partial explanation to the results of the studies that find an insignificant effect of aid on growth when using aggregate measures. In addition, a negative value of δ_P and a positive value of δ_U would illustrate the significance of the disaggregation of aid flows with respect to the time profile of their disbursements. This would also highlight the contrasting effects of the different types of aid and of their volatilities on growth.

Our benchmark model specification in equation [1] is originally estimated with OLS, and then with two methods that account for possible endogeneity of the regressors. These are a standard static GMM estimation and its dynamic equivalent developed by Blundell and Bond (1998). The instruments we use for the first technique include once lagged values of the potentially endogenous variables and exogenous variables drawn from Hansen and Tarp (2001) and Clemens *et al.* (2004). These are a dummy for Central American countries, a dummy for the African Franc Zone countries, a dummy for Egypt, time period dummies indicating one and two periods after the elapse of a civil war, once lagged arms imports relative to total imports, per capita GDP and its square, population and its square, and infant mortality rate and its square.[10] The second method of system GMM treats the model as a system of equations, in first-differences and in levels, where the endogenous variables are instrumented with lags of their levels and of their first differences.

In using the above instrumental variable approaches to examine our main hypothesis, we apply three specification tests to ensure the robustness of our results. First, we test the validity of the instruments with Hansen's J-statistic of over-identifying restrictions.[11] Second, we use the Arellano and Bond (1991) test to examine all of our regressions for first and second order degrees of serial correlation in the error terms. Because first-order serial correlation is identified in some of the regressions, we use clustered standard errors by country throughout making them robust to serial correlation.[12] Finally, we restrict the

[10] To minimize the possible estimation bias created by the exogenous set of instruments, we exclude variables that may be directly related to growth in the recipient country (i.e., policy and its lags; see Rajan and Subramanian (2005) for more details).

[11] Hansen's J-test is preferred over the Sargan test of over-identifying restrictions, since, unlike the latter, it is consistent in the presence of autocorrelation and heteroscedasticity (Roodman 2004).

[12] For the system GMM, however, since first-differencing induces first-order serial correlation in the transformed errors, the appropriate check regards only the absence of second-order serial correlation.

number of instruments to be less than the number of countries since otherwise the over-fitting of the instrumented variables may bias the results towards the OLS estimates.

2.2 Data

Our data set comprises panel data for 66 aid recipient countries over the period 1973-1998.[13] Most of the data are drawn from three different sources. The data on aid come from the OECD's *DAC* and *CRS* databases, while most of the rest of the data are from the World Bank's *World Development Indicators*. Details on the description and the sources of the variables can be found in the Appendix, Table A2. Although the data are based on annual observations, we remove the effects of the business cycle and extract the relevant long-run information by taking averages that correspond to each of the three decades (one eight-year and two nine-year time intervals: 1973-80, 1981-89, 1990-98). This standard approach in the growth literature allows an easy comparison with previous studies and also ensures compatibility with the theoretical analysis in section 4 that focuses on the effects of aid on trend growth.

Summary statistics for the data set can be found in Table 1. It is interesting to note that by our classification productive aid represents roughly 87% of all aid flows, while its volatility exceeds that of unproductive aid by a scale of three. At a higher level of disaggregation, short-impact aid constitutes about 55% of total aid flows and its volatility is greater than that of long-impact aid by about 50%. This preliminary statistics, therefore, indicate that although the productive types of aid comprise the largest share of total aid transfers, they also represent the most unstable ones.

3 Empirical Findings

This section conducts the estimation analysis and reports the results of the relationship between the different uses of aid receipts, their volatility, and economic growth. First, we present the basic findings and then we undertake a wide range of tests to examine their robustness for different specifications, time periodizations, more detailed disaggregations, and possible income threshold effects.

[13] The countries involved are listed in the Appendix.

3.1 Basic Results

Table 2 summarizes the basic findings. Originally we estimate a simpler version of equation [1] with OLS where we use aggregate measures of gross aid and its volatility. Subsequently we incorporate the disaggregated measures of aid and more control variables included in the vectors $X_{k,it}$ and $D_{l,it}$. Thereafter, as we move to the right of Table 2 we progressively allow more regressors to be endogenous.

The first column depicts the homogeneous effects of aid and aid volatility on growth, thus verifying the result first illustrated by Lensink and Morrissey (2000) – mainly, that aid significantly influences growth in a positive way while the volatility of aid inhibits growth.[14] Column (2) allows the empirical link between aid, aid volatility, and growth to vary depending on the use of aid by the recipient governments. These heterogeneous effects are captured by the disaggregation of aid into its productive and unproductive counterparts. The results exhibit a reasonably good fit, with the estimated effects of the two types of aid and their volatilities being strongly significant and entirely contrasting in nature. In particular, we find that aid disbursements used for productive purposes have a positive effect on growth, while the unproductive use of them reduces growth. Contrary, the volatility of aid is found to hurt growth only when aid is used productively, while the volatility of unproductive aid disbursements is associated with higher growth.

Column (3) adds the remaining conditioning variables described in equation [1]. The influence these variables exert on economic growth are in accordance to economic theory and the findings of past studies. Specifically, being situated in East Asia and having a more developed financial system are related with higher growth rates, while higher fertility rates adversely affect growth. We also find that although being situated in Sub-Saharan Africa, having a higher fraction of land in the tropics, and a higher initial GDP per capita (a higher initial life expectancy) are associated with slower (higher) growth, are not so to a statistically significant degree. Turning our attention to the variables of interest, we find that their signs have remained intact, and that all of them have increased in absolute magnitude, now being strongly significant at the 1% level.

[14] Pallage and Robe (2001) have raised a similar argument regarding the volatility of aid. They find the pattern of aid disbursements to be highly procyclical. This, by intensifying the volatility of output, may result in lower growth.

One possible drawback of the results presented thus far is that they may be biased by the endogeneity of some of the regressors. To overcome such a problem, we estimate the growth equation with GMM, where the instrumented variables are limited to the aid variables in column (4) and expanded to initial income and M2/GDP in column (5). These appear in bold type.

Column (4) shows that controlling for endogeneity improves the fit of the regression without altering the results. All the coefficients are similar in magnitude and significance, the only exception being the emergence of income convergence effects. Regression (5) utilizes an instrumental estimation approach that has been deemed to be superior to static GMM, the system GMM. This method accommodates all the variables that are considered to be endogenous and controls for them with their lagged levels as instruments. The results of this procedure continue to strongly support our underlying conclusions.

The specification tests in Table 2 as expressed by the Arellano-Bond (1991) test, although fails to reject the hypothesis of no first-order serial correlation in the error term just for regression (3), it fails to reject the hypothesis of no second-order autocorrelation in all regressions at the 5% level. Additionally, Hansen's (1982) *J* statistic, which examines the validity of the instruments in columns (4) and (5), cannot reject the hypothesis that the instruments are uncorrelated with the error term at the 5% level. The one-sided Wald-test that appears in the last row of the table examines the overall contribution of aid on growth by considering the sum of the coefficients of the two types of aid and their respective volatilities. As can be seen, the null hypothesis that this sum is negative cannot be rejected at any acceptable level of significance. This implies that when the volatility of aid is taken into account, the total effect of foreign aid on the recipient's rate of growth is negative. This is an issue that we will return again at the theoretical section of the paper.

The final point to note from our benchmark findings in Table 2 is that the coefficients in our variables of interest are fairly stable along the different regressions considering, in particular, the use of a variety of estimation techniques and number of instruments. The aim of the following sub-sections is to investigate the robustness of our findings in a more detailed manner.

3.2 Robustness Tests

Until recently, very few studies exploring the impact of aid on growth have examined the broader applicability of their results by means of robustness testing. However, the studies of Easterly (2003) and Roodman (2004) have demonstrated that most of the recent empirical results are susceptible to changes in specification, alternative periodizations, definition of variables, dataset expansion, and influential observations. To account for such considerations, we investigate in this section the sensitivity of our results to a number of alterations along these proposed lines. Our basic findings survive all these tests and clearly indicate the importance of considering jointly the disaggregation of aid flows by purpose and the pattern of their distribution in exploring the effectiveness of foreign aid on growth.

3.2.1 Testing the specification

Although the variables included in vector $X_{k,it}$ identify regressors that have been found relevant in the growth literature, the set is by no means comprehensive. To this extent, we examine the sensitivity of our findings by expanding vector $X_{k,it}$ with a number of additional control variables. These include secondary school enrolment (e.g., Barro and Sala-i-Martin 1995), land area (e.g., Radelet *et al.* 2001), black market premium (e.g., Barro and Sala-i-Martin 1995), and indicators of domestic policy and institutional quality as captured by the budget balance (fiscal), inflation (monetary), the Sachs-Warner index (openness), and the ICRGE index (institutions) (e.g., Burnside and Dollar 2000; Dalgaard *et al.* 2004; Clemens *et al.* 2004). Additionally, since the time horizon of nine years we consider is long enough for reverse causality to emerge running from growth to the policy and institutional indicators, we instrument them in our GMM framework.

The results appear in Table 3, where controlling for these additional factors and considering their potential endogeneity does not alter our conclusions in any way. The aid-related coefficients have the appropriate sign and are significant at least at the 5% level. All the additional controls have the expected sign, with the policy and institutional regressors significantly affecting economic growth.[15]

[15] We considered using as our benchmark specification one with all the indicators of domestic policy and institutional quality since they were all found to be significant at the 5% level. However, since this led to a loss of about a third of the observations, we use this specification as a robustness check of the basic findings.

The last regression of the table considers a restricted specification of the model where the volatility measures are set to have a zero coefficient $(\delta_P = \delta_U = 0)$. In this way, we can isolate the effects of productive and unproductive aid on growth when their disbursements are assumed not to impact growth. We observe that in the special case where the time profile of aid transfers is not allowed to play any role with respect to growth, then productive aid is conducive to growth while unproductive aid has no effect on growth. These results are consistent with recent studies that focus on different types of aid but ignore the relevance of their variability with respect to growth (e.g., Reddy and Minoiu 2006). Finally, note that the Hansen's *J*-statistic confirms the validity of the instrument set at the 5% level for all the regressions in the table.

3.2.2 Testing the periodization

It has become a standard procedure in cross-country growth regressions to use time period averages to capture the long-run effects of the conditioning variables on economic growth. In the aid-growth literature, almost all of the studies use either four-year or five-year periods, with the exception of Guillaumont and Chauvet (2001), who use twelve-year averages. Recently, however, Easterly (2003) and Roodman (2004) have shown that different periodizations can significantly alter the results of the most prominent empirical studies (e.g., Burnside and Dollar 2000; Collier and Hoeffler 2002; Collier and Dollar 2002). To encounter such an issue in this study, we consider the most commonly used alternative time period average of four-year intervals.

Table 4 reports results based on both static and dynamic GMM estimations for our basic specification as illustrated in equation [1]. Columns (1) and (3) reproduce the benchmark nine-year average regressions from Table 2 to ease comparison. Columns (2) and (4), based on four-year averages, show that our results remain materially unaffected by altering the periodization of the regression implying that decreasing the period averaging does not affect neither the magnitude nor the statistical power of the estimated coefficients of concern. This, in turn, seems to imply, once more, the importance of using disaggregated aid flows in growth regressions, rather than using an aggregate measure with substantial noise that creates difficulties in attributing its impact.

3.2.3 Testing the proxy of productive aid

In the preceding analysis, by summing over all the types of aid that are considered to be productive, we have implicitly assumed that all the categories of productive aid (and their variability) have the same impact on economic growth. An interesting exercise, therefore, would be to examine the potentially different effect of productive aid by disentangling short-impact from long-impact aid in the spirit of Clemens *et al.* (2004). In this way, we can investigate whether the results regarding productive aid are driven by one of its components. In addition, we can provide a check to Clemens *et al.*'s (2004) findings, who unveil that short-impact aid's marginal growth effect *largely* reflects its impact within a nine year period. Since we utilize nine-year average intervals, our estimations can provide a natural benchmark to test their conclusions.

For this purpose, we disaggregate productive aid into its short- and long-impact counterparts and include them along with their volatilities in our regression specification.[16] Table 5 reports the results. Column (1) depicts that short-impact aid is the only component of productive aid that retains its positive effect on growth, while its volatility is strongly negatively significant. Long-impact aid, on the other hand, is no longer significant, while its volatility is significant only at the 10% level. The results regarding humanitarian aid are (unsurprisingly) the same as for unproductive aid. These results clearly show that the relevant component of productive aid for growth within a nine-year period is short-impact aid, thereby providing support to Clemens *et al.* (2004).

Comparing the magnitude of the short-impact aid coefficients with the ones in Table 2, column (4) that uses productive aid, we observe greater estimates for both short-impact aid related regressors by roughly 50%, indicating the downward bias in the coefficients induced by the uniform treatment of short- and long-impact aid as equally productive. This becomes even more transparent in column (2), where we restrict the coefficients of long-impact aid and its volatility to zero. The coefficients of both short-impact aid and its volatility increase and their *p*-values fall to zero, suggesting that the standard errors in column (1) were inflated by the collinearity of short- and long-impact aid.

In columns (3) and (4) we conduct a robustness check where we add policy and institutional variables for which we instrument. Now, in column (3) both the coefficients

[16] The description and calculation of these variables can be found in the Appendix, Table A1 and A2. In addition, Table 1 presents their summary statistics.

related to long-impact aid are insignificant and the volatility of humanitarian aid becomes significant at the 10% level. However, dropping the insignificant variables establishes the significance of all the remaining variables of interest at least at the 5% level. Finally, column (5) excludes the volatility measures of short-impact and humanitarian aid to examine the effects of their mean values on growth, assuming that volatility does not matter for growth. The results suggest a positive effect of short-impact aid and a zero effect of humanitarian aid on growth, consistent with the finding in Table 3, column (7). Again, however, we observe an upward movement in the estimated coefficient, which more than doubles, and a drop in the *p*-value that constitutes the variable significant even at the 1% level.

Although, the last set of results illustrate that short-impact aid is a more accurate measure of aid that is conducive to growth than what we coined "productive" aid, our results in the previous sections are still of significance since they manage to capture the growth effect of productive aid despite the downward bias induced in the coefficients. With that view, our benchmark estimates can be thought of as representing the lower bound on the true coefficient of productive aid.

3.2.4 Testing income threshold effects

The final test we undertake is to re-examine the basic results for a sub-sample of low-income and lower-middle income countries, based on the fact that the country sample we use cannot be regarded as a homogeneous country grouping. Therefore, it is possible the effect of aid on growth to differ in magnitude and significance. From a theoretical point, such a view is supported by poverty trap models that advocate in favour of aid transfers as a stimulating mechanism for domestic savings and investment that will eventually place these countries to a sustained path of economic growth (e.g., Sachs *et al.* 2004).

Typically, income threshold effects are investigated with the use of interaction terms between the regressors of concern and income group dummy variables. However, since the majority of the countries in our sample fall into the low-income category in order to avoid a correlation problem between the aid variables and their interaction terms with income dummies, we choose to report findings from our benchmark model specification that is restricted to low income countries. Results appear in Table 6, where in columns (1) and (2) we run our standard regression that includes productive and unproductive aid in static and dynamic specifications respectively. Similarly, columns (3) and (4) depict the outcomes when

we instead use short-impact and humanitarian aid.[17] As in Reddy and Minoiu (2006), all the columns show that neither the significance nor the size of the effects is essentially altered compared to their full sample counterparts suggesting the non-existence of income threshold effects.

4 Theory

In this section, we build a simple stochastic growth model, the results of which will provide a suggestive theoretical rationalisation for the results obtained in the empirical analysis of our paper. The model's basic structure comprises an aid-recipient economy and a foreign donor (e.g., a country, a group of countries or an international organisation like the World Bank). There are two types of entities in the recipient economy – agents and a government. The engine of growth is the accumulation of – both private and public – physical capital. Private capital is accumulated by agents. Each period the government receives (random) foreign aid stipends which allocates between lump-sum income transfers to the private sector and – by combining them with revenues from taxation of domestic production – the formation of public capital.

4.1 The Basic Framework

Time is discrete, indexed by t and measured from 0 (the initial period) to ∞. We consider an artificial economy populated by a large number of identical, infinitely-lived producers-consumers. For simplicity, population growth is assumed to be zero and, without loss of generality, the total population size is normalised to unity. At the beginning of lifetime, each agent is endowed with an initial level of private capital equal to $k_0 > 0$, and the economy as a whole is endowed with an initial level of public capital equal to $G_0 > 0$.

Agents receive utility by the consumption of privately produced goods, denoted by c_t, according to

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \ln(c_t), \qquad [2]$$

[17] Long-impact aid and its volatility have been dropped from the model due to growth effects that are statistically indistinguishable from zero.

where E_0 is the conditional expectations operator and $\beta \in (0,1)$ is the discount factor.[18]

At the beginning of a period, each individual is endowed with a production technology through which she produces y_t units of a commodity by combining her previously accumulated capital stock, denoted by k_t, and publicly provided capital, denoted by G_t, according to

$$y_t = \Omega k_t^{\omega} G_t^{1-\omega}, \quad \Omega > 0, \ \omega \in (0,1). \qquad [3]$$

The representative agent can augment her physical capital stock by utilising a technology through which I_t^{priv} units of time-t output yield k_{t+1} units of physical capital available for time-$t+1$ production, according to $k_{t+1} = I_t^{priv} + (1-\delta^{priv})k_t$. Of course, the equilibrium level of private investment will be equal to the agent's saving, therefore $I_t^{priv} = (1-\tau_t)y_t + \mathrm{T}_t - c_t$, where τ_t is a proportional tax rate imposed by the government and T_t is a lump-sum income transfer that the individual receives from the government. To ensure analytical solutions, we assume full depreciation of private capital, that is $\delta^{priv}=1$. Therefore, the evolution of private capital is given by

$$k_{t+1} = (1-\tau_t)y_t + \mathrm{T}_t - c_t. \qquad [4]$$

The accumulation of publicly provided capital takes place according to $G_{t+1} = I_t^{pub} + (1-\delta^{pub})G_t$, where I_t^{pub} denotes public investment. For reasons of tractability, we will postulate full depreciation of public capital ($\delta^{pub}=1$) for the remaining analysis. As discussed earlier, the government can invest in public capital by combining domestic revenues and aid transfers by the donor, denoted by F_t.[19] Given the above, the evolution of public capital takes the form

$$G_{t+1} = \tau_t y_t + F_t. \qquad [5]$$

[18] Logarithmic preferences for consumption are essential for the derivation of closed-form solutions.

[19] Although we abscond from considerations of international borrowing mainly to keep the analysis tightly focused on capital investment decisions, this approach could be justified given evidence provided by Prati and Tressel (2006). They argue that the vast majority of aid recipient countries have accumulated very high levels of debt that severely restricts their capacity to borrow in international markets.

We assume that each period a foreign donor provides an income transfer to the economy equal to A_t, measured in units of domestic output. Following Chatterjee *et al.* (2003), it is further assumed that the government devotes a fraction $(1-\zeta) \in [0,1]$ of this aid inflow to the private sector of the economy in the form of lump-sum income transfers (*non-productive aid*) while the remaining fraction $\zeta \in [0,1]$ is used to enhance the accumulation of productive public capital (*productive aid*).[20] Without any loss of generality, we will assume that revenues from income taxation are used exclusively for the production of public goods, while the only source for financing lump-sum transfers comes from foreign aid inflows.[21] Given these assumptions, we have

$$\mathrm{T}_t = (1-\zeta) A_t, \qquad [6]$$

$$F_t = \zeta A_t. \qquad [7]$$

Our focus is to examine the effects of foreign aid along an equilibrium path with sustainable long-run growth. The existence of such an equilibrium requires that total aid disbursements are measured in proportion to the recipient's total income. Hence, following Chatterjee *et al.* (2003) and Chatterjee and Turnovsky (2007), we assume that

$$A_t = a_t y_t. \qquad [8]$$

Our point of departure from other analyses is that, in order to introduce aid volatility, we assume that $\{a_t\}_{t=0}^{\infty}$ is a sequence of identically and independently distributed random variables. In order to maintain clarity, we specify a simple probability distribution whereby

$$prob\{a_t = \widehat{a} - \sigma\} = prob\{a_t = \widehat{a} + \sigma\} = 0.5, \qquad [9]$$

where $\widehat{a}$ is used as a measure of the average (or permanent) level of foreign aid inflows and σ is an indicator of foreign aid volatility.[22] We impose the restriction $\widehat{a} \geq \sigma$ to ensure that aid receipts are nonnegative.

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[20] The reality is that the allocation of aid may be the outcome of many and complex dimensions involving the politico-economic environment within the recipient country and the negotiation procedure between governments and donors. Although these are very important issues, their analysis goes beyond the scope of this paper. For this reason we choose not to model them explicitly.

[21] The reason for using this assumption is that our focus is solely on the composition of foreign aid receipts.

[22] We use $\widehat{a}$ and σ as measures for aid and aid volatility, respectively, as in equilibrium the long-run rate of output growth depends solely on the foreign aid-to-output ratio, a_t, rather than on the actual level of aid

4.2 Dynamic General Equilibrium

The general equilibrium in this economy can be obtained by combining the assumptions of the previous section together with the first order conditions associated with the maximisation problem of the individual and the transversality condition on private capital.

Definition. *Given the initial values* $k_0, G_0 > 0$*, a dynamic, competitive equilibrium is a sequence of quantities* $\{c_t, y_t, \tau_t, A_t, F_t, \mathrm{T}_t, a_t, k_{t+1}, G_{t+1}\}_{t=0}^{\infty}$ *such that:*

(i) *Given* $\{\tau_t, A_t, F_t, \mathrm{T}_t, a_t, G_{t+1}\}_{t=0}^{\infty}$*, the quantities* $\{c_t, k_{t+1}\}_{t=0}^{\infty}$ *solve the representative agent's optimisation problem.*

(ii) *The goods market clears every period, i.e.,* $y_t + A_t = c_t + k_{t+1} + G_{t+1} \quad \forall t \geq 0$.

(iii) *The government's budget constraint is satisfied every period, i.e.,* $G_{t+1} = \tau_t y_t + F_t \quad \forall t \geq 0$.

The agent's objective is to choose sequences for $\{c_t\}_{t=0}^{\infty}$ and $\{k_{t+1}\}_{t=0}^{\infty}$ as to maximise the expected value of her lifetime utility, given in [2], subject to sequences for [3] and [4]. When maximising her lifetime utility, the representative agent takes the sequences of $\{G_{t+1}\}_{t=0}^{\infty}$, $\{\mathrm{T}_t\}_{t=0}^{\infty}$, $\{F_t\}_{t=0}^{\infty}$ and $\{A_t\}_{t=0}^{\infty}$ as given.

The first order conditions for the above problem are given as follows

$$\lambda_t = \frac{1}{c_t}, \qquad [10]$$

$$\lambda_t = \beta\omega\Omega E_t[\lambda_{t+1}(1-\tau_{t+1})k_{t+1}^{\omega-1}G_{t+1}^{1-\omega}], \qquad [11]$$

where λ_t is the Lagrange multiplier associated with [4] and E_t is the conditional expectations operator. Equation [10] is the familiar condition equating the shadow value of wealth with the marginal utility of consumption. Equation [11] is the dynamic optimality

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inflows, A_t. The randomness in a_t is meant to capture the empirically observed fact that in many instances, the variability in foreign aid provision is higher than the variability of the recipient economy's GDP (e.g., Pallage and Robe 2001).

condition, equating the marginal cost with the expected marginal benefit of an increment in private capital investment.

Multiplying both sides of equation [11] by k_{t+1} and substituting equations [3] and [10] yields

$$\frac{k_{t+1}}{c_t} = \beta\omega E_t\left[\frac{(1-\tau_{t+1})y_{t+1}}{c_{t+1}}\right]. \qquad [12]$$

Next we combine equations [4], [6] and [8] as to get

$$y_t = \frac{c_t + k_{t+1}}{1-\tau_t + (1-\zeta)a_t}. \qquad [13]$$

Now, substitute [13] in [12] to get

$$\frac{k_{t+1}}{c_t} = \beta\omega E_t\left[\frac{1-\tau_{t+1}}{1-\tau_{t+1}+(1-\zeta)a_{t+1}}\right] + \beta\omega E_t\left[\frac{1-\tau_{t+1}}{1-\tau_{t+1}+(1-\zeta)a_{t+1}}\frac{k_{t+2}}{c_{t+1}}\right]. \qquad [14]$$

Before we proceed with the solution of the model, we will utilise an assumption that will introduce a type of fiscal response by the government. Specifically, we assume that every period the government adjusts its policy as to keep the rate of public investment constant at

$$\frac{G_{t+1}}{y_t} = \overline{g}\,, \quad \overline{g} < 1\,. \qquad [15]$$

This assumption, can be combined together with [5], [7] and [8] to yield

$$\tau_t = \overline{g} - \zeta a_t\,, \qquad [16]$$

where the additional restriction $\hat{a} + \sigma < \overline{g}$ ensures positive tax rates. Equation [16] implies that a rise in aid receipts, when used to co-finance public capital investment, allow the government to reduce the tax rate on the private sector's income.[23]

Recall that, given [9], the sequence of random variables $\{a_t\}_{t=0}^{\infty}$ generate constant mean and variance. Given this and the transversality condition on capital,

[23] In this respect, our assumption concerning the use of foreign aid disbursements resembles the observations made by Boone (1996) (see Footnote 2). There are other analyses that provide some justification for our approach. Using a dynamic theoretical model, Kimbrough (1986) has shown that the reduction of the tax rate in response to receiving productive aid is an optimising behavior by the government. There is also empirical evidence arguing that recipients' tax revenues may respond negatively to the provision of aid (e.g., Leuthold 1991).

$\lim_{j\to\infty} \beta^j E_t[k_{t+j+1}/c_{t+j}] = 0$, we guess that the solution for k_{t+1}/c_t is a constant, say J, $\forall t$. Therefore, we can use this together with [16] in [14] and rewrite it as

$$J = \beta\omega\Psi + \beta\omega\Psi J, \qquad [17]$$

where, from [9]

$$\Psi = E_t\left[\frac{1-\overline{g}+\zeta a_{t+1}}{1-\overline{g}+a_{t+1}}\right] = \frac{1}{2}\left[\frac{1-\overline{g}+\zeta(\widehat{a}-\sigma)}{1-\overline{g}+\widehat{a}-\sigma} + \frac{1-\overline{g}+\zeta(\widehat{a}+\sigma)}{1-\overline{g}+\widehat{a}+\sigma}\right] \leq 1. \qquad [18]$$

The expression in [17] can be solved for $J = k_{t+1}/c_t$ to yield

$$\frac{k_{t+1}}{c_t} = \frac{\beta\omega\Psi}{1-\beta\omega\Psi}, \qquad [19]$$

a solution that satisfies the transversality condition on capital and can be verified by direct substitution back in the stochastic difference equation displayed in [14].

Our next step is to obtain the private saving rate. This can be done by substituting [6], [8], [16] and [19] in [4] and solving for k_{t+1}. Eventually, we get

$$k_{t+1} = \beta\omega\Psi(1-\overline{g}+a_t)\,y_t = s_t\,y_t. \qquad [20]$$

Proposition 1. *A temporary rise (fall) in the provision of aid increases (decreases) private capital investment.*

Proof. From [20], it is obvious that $\partial s_t / \partial a_t > 0$. ■

Intuitively, a temporary increase of foreign aid has two effects on physical capital investment. The fraction of aid used for public capital investment allows the government to reduce the income tax rate, thus leaving more available resources to individuals for both consumption and saving. This effect is reinforced by the fraction of aid used for transfer payments as it provides individuals with an additional source of income to consume and save.

Proposition 2. *A permanent rise (fall) in the provision of aid and a fall (rise) in its volatility decreases (increases) private capital investment, as long as some aid is allocated to lump-sum transfers. If the total*

amount of aid is allocated to the formation of public capital, changes in both the permanent part and the volatility of aid have no effect on private capital investment.

Proof. This follows from [20], where we observe that $\partial s_t / \partial \Psi > 0$, and from [18], where it is easy to establish that $\partial \Psi / \partial \widehat{a} < 0$ and $\partial \Psi / \partial \sigma > 0$ when $0 \leq \zeta < 1$. Furthermore $\partial \Psi / \partial \widehat{a} = 0$ and $\partial \Psi / \partial \sigma = 0$ when $\zeta = 1$. ■

The rationale for these results is the following: Current investment decisions yield benefits in the future as they affect next period's output, and therefore the expected utility from future consumption. The expectation of permanently higher aid (i.e., an increase in $\widehat{a}$) generates substitution and income effects with opposite impacts on private investment. On the one hand, it stimulates capital accumulation as individuals expect a future decrease in the tax rate, allowing them to substitute current for future consumption through saving. On the other hand, the expected future increase in disposable income and consumption (now, as a result of both the reduction in the tax rate and the available resources through income transfers) induces individuals to increase their current consumption by limiting the resources devoted for saving and, therefore, the accumulation of private capital. When $\zeta = 1$ the two effects cancel each other out, but as long as $\zeta < 1$ the second effect dominates. With respect to the effects of an increase in aid volatility (i.e., a higher σ), what is crucial is the non-linear manner through which a_{t+1} affects the expectation term in [18]. Inspection of this term reveals that it is convex in a_{t+1}. In terms of intuition, it shows that the increase in investment, resulting from an expected reduction in aid, is more pronounced than the decrease in investment, resulting from an expected raise in aid of equal magnitude. Aid volatility is a source of income uncertainty to which individuals react with a permanent precautionary increase of their capital investment.

4.3 Trend Growth and the Allocation of Volatile Aid

The economy's growth rate can be obtained by utilising [15] and [20], substituting in [3], and dividing both sides of the resulting expression by y_{t-1}. Eventually, we get

$$\frac{y_t}{y_{t-1}} = \Omega\left(\beta\omega\right)^{\omega} \overline{g}^{1-\omega} \Psi^{\omega} (1 - \overline{g} + a_{t-1})^{\omega}, \qquad [21]$$

where the solution for Ψ is given in [18]. It is evident, from equation [21], that the growth rate will vary with different realisations of a_{t-1} as a result of the response of private investment to temporary variations in foreign aid receipts. As this model includes a stochastic element, the *actual* (or temporary) growth rate becomes effectively a random variable with different realisations each period according to different realisations of a_{t-1}. To obtain the long-run, or *trend*, growth rate of output, $\hat{\gamma}$, we need to take account of the statistical properties of the distribution of a_{t-1}, given in [9], to compute its mean value. Taking expectations on [21] and using [9] yields

$$Mean\left(\frac{y_t}{y_{t-1}}\right) = \Omega\left(\beta\omega\right)^{\omega} \frac{\overline{g}^{1-\omega}}{2} \Psi^{\omega}[(1-\overline{g}+\hat{a}-\sigma)^{\omega} + (1-\overline{g}+\hat{a}+\sigma)^{\omega}] \equiv \hat{\gamma}\,. \qquad [22]$$

The growth rate in [22] together with [18] reveal that, *ceteris paribus*, the impact of a change in both the average (or permanent) level of aid inflows and in the degree of aid volatility depends crucially on the parameter ζ which determines the allocation of foreign aid by the recipient economy, i.e., whether aid disbursements are distributed to agents in the form of income transfers or used to expand the accumulation of public capital. To make the argument more transparent, we can treat ζ as a binary (or indicator) parameter and consider the two extremes in which either $\zeta = 1$ (*productive aid*) or $\zeta = 0$ (*non-productive aid*).

Proposition 3. *Suppose that foreign aid receipts are used purely for public capital investment. Then a permanent increase (decrease) in aid and a decrease (increase) in its volatility enhances (impedes) trend growth for the recipient economy.*

Proof. From [18] check that when $\zeta = 1$ then $\Psi = 1$. After substitution of this in [22] it is straightforward to show that $\partial\hat{\gamma} / \partial\hat{a} > 0$ and $\partial\hat{\gamma} / \partial\sigma < 0$. ■

Recall that in Propositions 1 and 2 we established that when $\zeta = 1$ only temporary variations in foreign aid impinge on the agents' saving rate. Consequently, this is the only channel through which the effects of aid impinge on trend growth. The production technology, for a given level of public capital, exhibits a diminishing marginal product of private capital. Together with [20], this explains the concavity of the temporary growth rate

with respect to a_{t-1}. The temporary rise in growth resulting from a temporary increase in foreign aid is not as strong as the temporary reduction in growth resulting from a decrease in foreign aid of equal magnitude. Consequently, aid volatility (i.e., σ) leaves the growth rate lower on average. Naturally, trend growth responds positively to the permanent part of foreign aid (i.e., $\widehat{a}$) as this corresponds to a permanent increase in private investment (due to the lower tax rate) when $\zeta = 1$.

Proposition 4. *Suppose that foreign aid receipts are used purely for the distribution of lump-sum transfers to the private sector. Then a permanent increase (decrease) in aid and a decrease (increase) in its volatility impedes (enhances) trend growth for the recipient economy.*

Proof. Substituting $\zeta = 0$ in [18] yields $\Psi = \dfrac{(1-\overline{g})(1-\overline{g}+\widehat{a})}{(1-\overline{g}+\widehat{a})^2 - \sigma^2}$. Given this, the growth rate in [22] equals

$$\widehat{\gamma} = \Omega\left(\beta\omega\right)^{\omega} \frac{\overline{g}^{1-\omega}}{2}[(1-\overline{g})(1-\overline{g}+\widehat{a})]^{\omega}\left[\left(\frac{1}{1-\overline{g}+\widehat{a}-\sigma}\right)^{\omega} + \left(\frac{1}{1-\overline{g}+\widehat{a}+\sigma}\right)^{\omega}\right].$$

Some further algebra reveals that $\partial\widehat{\gamma}/\partial\widehat{a} < 0$ and $\partial\widehat{\gamma}/\partial\sigma > 0$. ■

When aid receipts are used for the provision of transfer payments to the private sector, there are two channels through which $\widehat{a}$ and σ transmit their effects on long-run growth. One channel comes through the presence of a_{t-1} in the growth equation, reflecting the increase in saving due to the higher disposable income. The corresponding growth effects of foreign aid are similar to that described in the analysis of Proposition 3. The other channel comes through the effects that the permanent component of aid and its volatility have on private capital investment (and, consequently, trend growth) when a only a fraction of aid receipts contributes to the accumulation of public capital. As we recall from Proposition 2, private capital investment (under such circumstances) is negatively related with $\widehat{a}$ and positively related with σ - effects which are transmitted to long-run growth through private capital accumulation. As it turns out, these effects actually dominate in magnitude when $\zeta = 0$.

4.4 Aid Volatility and Effectiveness

So far, our dynamic general equilibrium model has been able to provide an intuitive rationale behind the results of the econometric analysis that illustrated how the effects of volatile aid on economic growth can be classified in relation to the allocation of aid transfers between productive and non-productive uses.

Moreover, our theoretical model is able to reproduce and explain an even more important insight which emerged from our econometric study. This has to do with the fact that the mere presence of volatility in aid disbursements adds a further dimension on the foreign aid-economic growth nexus. To illustrate this, let us first see how foreign aid affects growth in the absence of volatility.

Proposition 5. *Suppose that foreign aid is not volatile. Then a permanent increase (decrease) in aid enhances (impedes) trend growth for the recipient economy, as long as some aid is allocated to the formation of public capital. If the whole amount of aid is allocated to the provision of lump-sum transfers, any change in foreign aid has no effect on trend growth.*

Proof. Set $\sigma = 0$ in [18] and [22]. Then it can be established that $\partial\widehat{y} / \partial\widehat{a} > 0$ when $\zeta > 0$ and $\partial\widehat{y} / \partial\widehat{a} = 0$ when $\zeta = 0$. ■

The intuition for this result can be explained once we recall that the channel through which foreign aid impinges on growth is its effect on private investment – either because it allows a reduction in the tax rate when it partially finances public capital investment or because it gives an additional source of income when distributed as a transfer. Now, let us revisit equations [18] and [20], but setting $a_t = \widehat{a}$ since $\sigma = 0$. We can see that in the deterministic case, the temporary effect that creates a wedge between current and anticipated future events – something crucial in the stochastic model – is absent. When $\zeta = 0$ the increase in saving due to more resources is counter-balanced by the decrease in saving generated from the income effect. As long as $\zeta > 0$, the substitution effect from the reduced tax rate kicks in and the positive growth effect of aid is always dominant. Hence, foreign aid results in a boost of capital accumulation and, therefore, growth.[24]

[24] Recall that these findings were empirically illustrated in Table 3, column (7) and Table 5, column (5).

The preceding analysis, when contrasted with the analysis of the stochastic model, introduces an important consideration which is summarised below.

Corollary. *The effect of foreign aid on the recipient's growth rate may be negative if and only if aid is volatile.*

This result can be deduced from the discussion of Propositions 4 and 5. When a large part of foreign aid is allocated to activities that are not directly productive or are even non-productive – in our case, lump-sum transfer payments – then whether aid is volatile or not may actually determine whether it inhibits or promotes the growth prospect of the recipient economy. Indeed, our discussion of Propositions 3 and 4 implied that there exists some critical threshold of aid allocation (as described by ζ), below which foreign aid has, on average, a negative effect on growth. Now, we see that it is not the allocation rule *per se* that may render aid detrimental for long-run growth. Instead, there are situations where below such thresholds, aid may still promote growth but only if it is not volatile. As a consequence, the results of the empirical analysis (documented by the outcome of the Wald test in Table 2) find a clear interpretation: It is the allocation of *volatile* aid flows that is important in determining whether these flows alter the growth performance of the recipients for better or for worse.

5 Conclusions

The objective of this paper has been to evaluate the relationship between foreign aid and economic growth. Our contribution lies on identifying, *both* theoretically *and* empirically, the volatility of aid flows – documented by the studies of Pallage and Robe (2001) and Bulíř and Hamann (2003, 2006) – as an additional factor on the determination of the growth effects generated by the provision of aid.

Specifically, we distinguish the effects of aid transfers and their volatility according to whether foreign resource inflows are utilised for financing productive or non-productive public spending. The general conclusion emerging from our analysis can be summarised as follows: When aid is used productively (unproductively) it has, *on average*, a positive (negative) effect on growth while its respective volatility has a negative (positive) growth effect. Even

more significant is our argument that scenarios in which aid can actually hurt trend output growth in the recipient arise only in cases where foreign aid is volatile.

From a policy perspective, our results seem to suggest that the scope for a higher effectiveness of aid on stimulating growth is not purely an one-sided issue. Undoubtedly, recipient governments have to ensure and establish the conditions that will allow the economy to benefit from the provision of foreign aid (e.g., through appropriate macroeconomic management, establishment of essential economic, political and legal institutions etc.). On their behalf, however, donors should act analogously by creating conditions which allow aid provision to benefit recipient economies on a more permanent basis. Our analysis suggests that one such condition is that productive aid provision should be the least erratic possible.

The need to keep our theory tractable and tightly focused means that our analysis, together with the previous studies on the foreign aid-economic growth nexus, shares a fair number of restrictions. One such restriction is that our analysis abstracts from the important issue of poverty reduction. Insofar as income transfers can alleviate, to some extent, the severely adverse effects resulting from situations of extreme poverty (i.e., high mortality rates, restrictions on undertaking costly activities that promote future productivity) then one can identify additional channels through which foreign aid and its volatility impinge on trend output growth. Another shortcoming is that we have considered the provision of aid and its distribution on different uses as exogenously given, without specifying any kind of preferences for either donors or recipients. To the extent that the inclusion of such preferences may result in strategic interactions in the decisions between donors and recipients, then the possibility of multiple equilibria may actually provide an explanation of why aid disbursements are volatile.

Although removing such restrictions will make the analysis richer – and for this reason it may constitute a promising avenue for future research – it is our belief that our framework, even in its current form, is sufficient to draw attention to some additional and important implications on the growth effects of foreign aid.

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Table 1
Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
GDP p.c. growth rate	0.888	2.75	-8.65	7.35
Gross aid	8.45	10.18	0.037	56.48
Volatility of gross aid	3.22	5.23	0.012	30.24
Productive aid	7.32	8.18	0.013	36.89
Unproductive aid	1.13	4.70	0.0006	44.89
Volatility of productive aid	2.83	3.75	0.012	17.69
Volatility of unproductive aid	0.952	3.67	0.0003	33.01
Short-impact aid	4.62	5.17	0.012	24.39
Long-impact aid	2.71	3.40	0.002	18.03
Humanitarian aid	1.13	4.70	0.0006	44.89
Volatility of short-impact aid	2.32	2.85	0.013	18.18
Volatility of long-impact aid	1.47	2.10	0.0018	12.23
Volatility of humanitarian aid	0.952	3.67	0.0003	33.01
Aid repayments (log)	-0.967	1.33	-4.62	2.14
Initial p.c. GDP (log)	6.83	1.03	4.60	8.98
M2/GDP	37.08	37.48	8.36	346.90
East Asia	0.082	0.276	0	1
Sub-Saharan Africa	0.319	0.468	0	1
Fertility rate	4.57	1.60	1.72	7.72
Tropical	0.680	0.468	0	1
Initial life expectancy (log)	4.07	0.164	3.69	4.32

Notes: All variables are based on 9-year averages of the data. The variables gross aid, productive aid, unproductive aid, and M2 are expressed as fractions of GDP. The volatility of a variable is defined as its standard deviation. Initial GDP, aid repayments, and initial life expectancy enter in log form, while East Asia, Sub-Saharan Africa, and Tropical enter as 0/1 dummies.

Table 2
Basic Findings

	(1) OLS	(2) OLS	(3) OLS	(4) GMM	(5) GMM-SYS
Initial GDP per capita (log)	0.694	0.724	-0.266	-0.795	**-0.040**
	(0.003)	(0.002)	(0.347)	(0.000)	**(0.959)**
Gross aid	0.098				
	(0.054)				
Volatility of gross aid	-0.314				
	(0.002)				
Productive aid		0.166	0.227	**0.234**	**0.267**
		(0.004)	(0.000)	**(0.000)**	**(0.000)**
Unproductive aid		-0.444	-0.882	**-1.34**	**-1.27**
		(0.009)	(0.000)	**(0.000)**	**(0.000)**
Volatility of productive aid		-0.539	-0.601	**-0.746**	**-0.704**
		(0.000)	(0.000)	**(0.000)**	**(0.000)**
Volatility of unproductive aid		0.550	0.941	**1.25**	**1.33**
		(0.019)	(0.000)	**(0.001)**	**(0.001)**
Aid repayments (log)	0.216	0.277	0.350	**-0.109**	**0.341**
	(0.232)	(0.122)	(0.076)	**(0.511)**	**(0.278)**
M2/GDP			0.026	0.044	**0.042**
			(0.001)	(0.000)	**(0.011)**
East Asia			2.30	1.36	1.86
			(0.000)	(0.009)	(0.012)
Sub-Saharan Africa			-0.615	-0.156	-0.529
			(0.310)	(0.731)	(0.575)
Fertility rate			-0.563	-0.898	-0.589
			(0.029)	(0.000)	(0.046)
Tropical			-0.551	-0.294	-0.312
			(0.207)	(0.399)	(0.541)
Initial life expectancy (log)			0.992	-1.57	-0.425
			(0.728)	(0.352)	(0.925)
Countries / Observations	66 / 172	66 / 172	63 / 166	54 / 105	63 / 166
R^2	0.205	0.243	0.527	0.552	
Number of Instruments	-	-	-	28	43
Hansen J-statistic *(p-value)*	-	-	-	0.341	0.192
AR(1) test *(p-value)*	0.0001	0.0002	0.868	0.061	0.001
AR(2) test *(p-value)*	0.123	0.164	0.957	-	-
One-sided Wald-test *(p-value)*	0.999	0.997	0.999	0.999	0.999

Notes: p-values in parentheses based on robust and clustered by country standard errors. Constant term and time dummies not reported. Instrumented variables are in bold type. Instruments in regression (4): dummies for Central American countries, African Franc Zone countries, Egypt, and post-conflict 1 and post-conflict 2 periods, lagged arms imports as a fraction of total imports, GDP per capita and its square, population and its square, infant mortality rate and its square, each of the lagged aid variables, the lagged volatility of the aid variables, and the lagged productive and unproductive aid variables interacted with population. Instruments in regression (5): one to three time lags of the endogenous variables.

Table 3
Testing the specification: additional controls

	(1) GMM	(2) GMM	(3) GMM	(4) GMM	(5) GMM	(6) GMM	(7) GMM
Initial GDP per capita (log)	-0.935	-1.08	-0.905	-1.06	-0.573	-0.785	**-0.914**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	**(0.000)**
Productive aid	**0.203**	**0.274**	**0.215**	**0.258**	**0.294**	**0.215**	**0.078**
	(0.003)	**(0.000)**	**(0.001)**	**(0.018)**	**(0.000)**	**(0.000)**	**(0.028)**
Unproductive aid	**-1.15**	**-1.06**	**-1.34**	**-4.01**	**-1.93**	**-1.66**	**-0.052**
	(0.001)	**(0.000)**	**(0.000)**	**(0.020)**	**(0.024)**	**(0.018)**	**(0.775)**
Volatility of productive aid	**-0.683**	**-0.895**	**-0.674**	**-0.540**	**-0.635**	**-0.442**	
	(0.000)	**(0.000)**	**(0.000)**	**(0.013)**	**(0.000)**	**(0.001)**	
Volatility of unproductive aid	**1.12**	**1.15**	**1.28**	**3.79**	**2.15**	**1.69**	
	(0.005)	**(0.001)**	**(0.001)**	**(0.022)**	**(0.015)**	**(0.031)**	
Aid repayments (log)	**0.011**	**-0.180**	**-0.097**	**-0.409**	**-0.374**	**-0.402**	**-0.584**
	(0.953)	**(0.169)**	**(0.613)**	**(0.044)**	**(0.004)**	**(0.018)**	**(0.001)**
M2/GDP	0.033	0.028	0.042	0.031	0.003	0.008	**0.002**
	(0.018)	(0.001)	(0.000)	(0.003)	(0.666)	(0.412)	**(0.810)**
East Asia	1.60	1.72	1.53	1.30	1.24	1.06	1.13
	(0.002)	(0.000)	(0.011)	(0.030)	(0.000)	(0.005)	(0.015)
Sub-Saharan Africa	0.185	0.036	0.04	-0.082	-1.94	-1.86	-0.971
	(0.710)	(0.944)	(0.992)	(0.911)	(0.000)	(0.000)	(0.057)
Fertility rate	-0.922	-0.808	-0.931	-1.38	-1.00	-0.864	-1.01
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tropical	-0.380	-0.306	-0.364	-0.720	-0.982	-1.13	-1.33
	(0.316)	(0.322)	(0.346)	(0.022)	(0.000)	(0.000)	(0.000)
Initial life expectancy (log)	-0.509	2.14	-0.632	-4.48	-6.38	-6.58	-3.99
	(0.732)	(0.232)	(0.710)	(0.175)	(0.001)	(0.000)	(0.042)
Initial secondary school enrollment ratio	0.011 (0.451)						
Land area		0.00141 (0.001)					
Black market premium			-0.0001 (0.462)				
Budget balance				**0.198** **(0.003)**			
Inflation					-1.95 (0.000)	**-2.03** **(0.000)**	**-3.27** **(0.000)**
Openness (Sachs-Warner)					0.995 (0.017)	**1.32** **(0.010)**	**1.39** **(0.035)**
Institutional quality					0.221 (0.010)	**0.407** **(0.002)**	**0.274** **(0.088)**
Countries / Observations	53 / 102	53 / 103	53 / 102	41 / 72	43 / 82	40 / 75	40 / 75
R^2	0.593	0.579	0.576	0.719	0.783	0.808	0.769
Number of Instruments	29	29	29	29	31	31	29
Hansen J-statistic *(p-value)*	0.573	0.167	0.581	0.753	0.214	0.239	0.423
AR(1) test *(p-value)*	0.054	0.106	0.072	0.865	0.097	0.130	0.716
AR(2) test *(p-value)*	-	-	-	-	-	-	-

Notes: p-values in parentheses based on robust and clustered by country standard errors. Constant term and time dummies not reported. Instrumented variables are in bold type. Instruments in regressions (1)-(7): as in Table 2 regression (4). Regression (4) also adds as instrument the lagged budget balance, while regression (6) adds the lagged values of inflation, openness, and institutional quality. Additionally, regression (7) includes the lagged values of log(initial GDP pc) and M2/GDP.

Table 4
Testing the time interval: alternative periodization

	(1) GMM 9-year average	(2) GMM 4-year average	(3) GMM-SYS 9-year average	(4) GMM-SYS 4-year average
Initial GDP per capita (log)	-0.795	-0.567	**-0.040**	**0.130**
	(0.000)	(0.016)	**(0.959)**	**(0.855)**
Productive aid	**0.234**	**0.166**	**0.267**	**0.159**
	(0.000)	**(0.006)**	**(0.000)**	**(0.039)**
Unproductive aid	**-1.34**	**-1.81**	**-1.27**	**-1.22**
	(0.000)	**(0.000)**	**(0.000)**	**(0.033)**
Volatility of productive aid	**-0.746**	**-0.578**	**-0.704**	**-0.431**
	(0.000)	**(0.001)**	**(0.000)**	**(0.019)**
Volatility of unproductive aid	**1.25**	**2.55**	**1.33**	**1.84**
	(0.001)	**(0.000)**	**(0.001)**	**(0.007)**
Aid repayments (log)	**-0.109**	**0.122**	**0.341**	**0.148**
	(0.511)	**(0.590)**	**(0.278)**	**(0.604)**
M2/GDP	0.044	0.034	**0.042**	**0.030**
	(0.000)	(0.000)	**(0.011)**	**(0.066)**
East Asia	1.36	0.974	1.86	1.25
	(0.009)	(0.103)	(0.012)	(0.216)
Sub-Saharan Africa	-0.156	-0.532	-0.529	-0.962
	(0.731)	(0.400)	(0.575)	(0.417)
Fertility rate	-0.898	-1.21	-0.589	-1.03
	(0.000)	(0.000)	(0.046)	(0.009)
Tropical	-0.294	-0.494	-0.312	-0.142
	(0.399)	(0.215)	(0.541)	(0.801)
Initial life expectancy (log)	-1.57	-2.65	-0.425	-4.31
	(0.352)	(0.333)	(0.925)	(0.528)
Countries / Observations	54 / 105	62 / 304	63 / 166	65 / 370
R^2	0.552	0.264		
Number of Instruments	28	29	43	107
Hansen J-statistic *(p-value)*	0.341	0.278	0.192	1.00
AR(1) test *(p-value)*	0.061	0.082	0.001	0.045
AR(2) test *(p-value)*	-	0.421	-	0.404

Notes: p-values in parentheses based on robust and clustered by country standard errors. Constant term and time dummies not reported. Instrumented variables are in bold type. Columns (1) and (3) are reproductions of columns (4) and (5) of Table 2 respectively. Instruments in regressions (2) and (4): as in regressions (1) and (3) respectively.

Table 5
Testing the proxy of productive aid: a more detailed disaggregation

	(1) GMM	(2) GMM	(3) GMM	(4) GMM	(5) GMM
Initial GDP per capita (log)	-0.918	-1.06	**-0.903**	**-0.765**	**-0.945**
	(0.000)	(0.000)	**(0.000)**	**(0.001)**	**(0.000)**
Short-impact aid	**0.361**	**0.388**	**0.485**	**0.272**	**0.191**
	(0.003)	**(0.000)**	**(0.000)**	**(0.002)**	**(0.003)**
Long-impact aid	**0.128**		**-0.077**		
	(0.290)		**(0.617)**		
Humanitarian aid	**-1.41**	**-1.62**	**-1.51**	**-2.35**	**-0.140**
	(0.000)	**(0.000)**	**(0.024)**	**(0.000)**	**(0.504)**
Volatility of short-impact aid	**-0.936**	**-1.10**	**-0.341**	**-0.391**	
	(0.000)	**(0.000)**	**(0.022)**	**(0.023)**	
Volatility of long-impact aid	**-0.277**		**-0.319**		
	(0.074)		**(0.263)**		
Volatility of humanitarian aid	**1.41**	**1.56**	**1.38**	**2.38**	
	(0.003)	**(0.005)**	**(0.068)**	**(0.001)**	
Aid repayments (log)	**-0.078**	**-0.126**	**-0.645**	**-0.544**	**-0.672**
	(0.615)	**(0.445)**	**(0.000)**	**(0.001)**	**(0.000)**
M2/GDP	0.050	0.064	**0.003**	**0.013**	**0.0004**
	(0.000)	(0.000)	**(0.723)**	**(0.125)**	**(0.962)**
East Asia	1.27	0.896	1.08	0.628	1.20
	(0.059)	(0.230)	(0.012)	(0.119)	(0.010)
Sub-Saharan Africa	0.498	0.735	-2.10	-1.60	-1.02
	(0.198)	(0.079)	(0.000)	(0.001)	(0.042)
Fertility rate	-0.832	-0.845	-0.828	-0.918	-1.03
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Tropical	-0.427	-0.221	-0.803	-1.06	-1.34
	(0.228)	(0.514)	(0.000)	(0.000)	(0.000)
Initial life expectancy (log)	1.28	0.971	-3.71	-7.10	-3.20
	(0.559)	(0.610)	(0.067)	(0.000)	(0.092)
Inflation			**-2.38**	**-2.44**	**-3.40**
			(0.000)	**(0.000)**	**(0.000)**
Openness (Sachs-Warner)			**1.17**	**1.74**	**1.37**
			(0.012)	**(0.000)**	**(0.048)**
Institutional quality			**0.237**	**0.282**	**0.203**
			(0.079)	**(0.043)**	**(0.195)**
Countries / Observations	54 / 103	54 / 103	40 / 74	40 / 74	40 / 75
R^2	0.528	0.435	0.795	0.797	0.756
Number of Instruments	31	29	34	32	29
Hansen J-statistic *(p-value)*	0.578	0.546	0.230	0.374	0.471
AR(1) test *(p-value)*	0.140	0.188	0.202	0.638	0.737
AR(2) test *(p-value)*	-	-	-	-	-

Notes: p-values in parentheses based on robust and clustered by country standard errors. Constant term and time dummies not reported. Instrumented variables are in bold type. Instruments in regressions (1)-(5): as in Table 2 regression (4). Regressions (3)-(5) also add as instruments the lagged values of inflation, openness, institutional quality, log(initial GDP pc), and M2/GDP.

Table 6
Testing sub-samples: income threshold effects

	(1) GMM	(2) GMM-SYS	(3) GMM	(4) GMM-SYS
Initial GDP per capita (log)	-0.377	**0.768**	-1.33	**-1.28**
	(0.107)	**(0.558)**	(0.000)	**(0.170)**
Productive aid	**0.288**	**0.260**		
	(0.000)	**(0.000)**		
Unproductive aid	**-1.88**	**-1.11**		
	(0.000)	**(0.011)**		
Volatility of productive aid	**-0.894**	**-0.663**		
	(0.000)	**(0.000)**		
Volatility of unproductive aid	**1.79**	**1.20**		
	(0.000)	**(0.011)**		
Aid repayments (log)	**-0.377**	**0.679**	**-0.185**	**0.369**
	(0.107)	**(0.043)**	**(0.406)**	**(0.169)**
Short-impact aid			**0.430**	**0.224**
			(0.000)	**(0.002)**
Humanitarian aid			**-2.37**	**-0.574**
			(0.000)	**(0.034)**
Volatility of short-impact aid			**-1.26**	**-0.503**
			(0.000)	**(0.008)**
Volatility of humanitarian aid			**2.24**	**0.550**
			(0.000)	**(0.041)**
M2/GDP	0.067	**0.033**	0.099	**0.021**
	(0.000)	**(0.075)**	(0.000)	**(0.192)**
East Asia	0.593	2.09	-0.398	2.21
	(0.347)	(0.042)	(0.640)	(0.001)
Sub-Saharan Africa	-0.376	-1.24	0.883	-0.313
	(0.407)	(0.212)	(0.104)	(0.784)
Fertility rate	-0.746	-0.547	-0.686	-0.395
	(0.000)	(0.100)	(0.000)	(0.131)
Tropical	0.565	-0.592	1.17	-0.487
	(0.741)	(0.365)	(0.006)	(0.575)
Initial life expectancy (log)	-2.69	-3.97	1.21	6.11
	(0.104)	(0.561)	(0.519)	(0.167)
Countries / Observations	42 / 82	46 / 125	42 / 82	46 / 125
R^2	0.352		0.126	
Number of Instruments	28	43	29	43
Hansen J-statistic *(p-value)*	0.753	0.311	0.468	0.329
AR(1) test *(p-value)*	0.099	0.002	0.239	0.001
AR(2) test *(p-value)*	-	-	-	-

Notes: p-values in parentheses based on robust and clustered by country standard errors. Constant term and time dummies not reported. Instrumented variables are in bold type. Instruments in regressions (1)-(4): as in Table 2 regression (4). Instruments in regressions (2) and (4): one to three time lags of the endogenous variables.

Country and Data Appendix

Country Sample (66)

Argentina, Belarus, Belize, Bhutan, Bolivia, Brazil, Bulgaria, Burkina Faso, Burundi, Cameroon, Chile, Colombia, Congo Dem. Rep., Congo Rep., Costa Rica, Cote d'Ivoire, Cyprus, Dominican Rep., Egypt, Estonia, Ethiopia, Gambia, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Iran, Israel, Korea Rep., Lesotho, Liberia, Madagascar, Malaysia, Mali, Malta, Mauritius, Mexico, Mongolia, Morocco, Nepal, Nicaragua, Pakistan, Panama, Paraguay, Peru, Poland, Romania, Rwanda, Senegal, Seychelles, Slovenia, Sri Lanka, Suriname, Syrian Arab Rep., Tanzania, Thailand, Togo, Tonga, Tunisia, Turkey, Uruguay, Yemen Rep., Zambia, Zimbabwe.

Table A1
Classification of Aid Flows

Productive aid "P"		*Unproductive aid "U"*
Short-impact "S"	Long-impact "L"	Humanitarian "H"
152 Conflict, Peace and Security	110 Education	520 Developmental Food Aid/ Food Security Assistance
210 Transport and Storage	120 Health	710 Emergency Food Aid
220 Communications	130 Population Policies/Programmes and Reproductive Health	720 Other Emergency and Distress Relief
230 Energy Generation and Supply	140 Water Supply and Sanitation	730 Reconstruction Relief
240 Banking and Financial Services	151 Government and Civil Society	
250 Business and Other Services	160 Other Social Infrastructure and Services	
311 Agriculture	323 Construction	
312 Forestry	332 Tourism	
313 Fishing	410 General Environmental Protection	
321 Industry	420 Women in Development	
322 Mining and Mineral Resources	430 Other Multisectoral	
331 Trade Policy and Regulations	920 Support to NGO's	
510 General Budget Support	998 Unallocated/Unclassified	
530 Other General Programme and Commodity Assistance		
600 Action Relating to Debt		

Note: the classification of aid into productive/unproductive and into short-impact/long-impact/humanitarian follows Clemens *et al.* (2004) at the three-digit level based on the OECD's CRS.

Table A2
Variables Description and Sources

Variable	Definition	Source
Basic Set		
Productive and unproductive aid	"Productive" aid is the product across all donors, for each recipient, of "Total ODA (OA) Gross Disbursements" from the online DAC database, Table 2a, with the elements of the CRS field "usd_amount" classified as "P" in Table A1, divided by the sum of all aid in CRS field "Total ODA (OA) Commitments", multiplied by 100. "Unproductive" aid is calculated in a similar way, according to the "U" classification in Table A1 (% of GDP in current USD from WDI (2003)).	OECD, *DAC* (online) and *CRS* (online) based on Clemens et al. (2004)
Volatility of productive (unproductive) aid	Standard deviation of productive (unproductive) aid flows.	OECD, *DAC* (online) and *CRS* (online)
Short-impact, Long-impact, and Humanitarian aid	Calculations similar to the categories of "P" and "U" aid, but now according to the "S", "L", and "H" classifications in Table A1.	OECD, *DAC* (online) and *CRS* (online) based on Clemens et al. (2004)
Volatility of short-impact (long-impact) [humanitarian] aid	Standard deviation of short-impact (long-impact) [humanitarian] aid flows.	OECD, *DAC* (online) and *CRS* (online)
Gross aid	Official development assistance and gross official aid (% of GDP in current USD from WDI (2003)).	OECD, *DAC* CD-ROM (2003)
Volatility of gross aid	Standard deviation of gross aid flows.	OECD, *DAC* (2003)
Aid repayments	"Total ODA (OA) Gross" minus "Total ODA (OA) Net" from the DAC CD-ROM (2003) and DAC online, respectively (% of GDP in current USD from WDI (2003)).	OECD, *DAC* CD-ROM (2003 and online) and *WDI* (2003)
GDP p.c. growth rate	Annual percentage growth rate of GDP per capita based on constant local currency.	World Bank, *WDI* (2003)
Initial p.c. GDP	GDP per capita in constant 1995 USD for the first year of the period.	World Bank, *WDI* (2003)
M2/GDP	Money and quasi money (% of GDP in current USD from WDI (2003)).	World Bank, *WDI* (2003)
East Asia	Dummy indicating region.	World Bank
Sub-Saharan Africa	Dummy indicating region.	World Bank
Fertility rate	Fertility rate (births per woman), total.	World Bank, *WDI* (2003)
Tropical	Dummy indicating tropical location.	World Bank, Global Development Network
Initial life expectancy	Life expectancy at birth, total.	World Bank, *WDI* (2003)
Instruments Set		
Central America	Dummy for Central American countries.	World Bank
Franc Zone	Dummy for African Franc Zone countries.	World Bank
Egypt	Dummy for Egypt.	
Post-conflict1 (Post-conflict2)	Dummy that takes the value of 1 one (two) period(s) after civil war has ended.	Collier and Hoeffler (2002)
Lagged arms imports	Lagged arms imports as a fraction of total imports.	Roodman (2004)
Population	Population, total.	World Bank, *WDI* (2003)
Infant mortality rate	Mortality rate, infant (per 1,000 live births)	World Bank, *WDI* (2003)
Sensitivity Set		
Initial secondary school enrollment ratio	Gross ratio of total enrollment, regardless of age, to the population of the secondary school age group, for the first year of the period.	World Bank, *WDI* (2003)
Land area	Kilometers.	World Bank, Global Development Network
Black market premium		World Bank, *WDI* (2003)

Budget balance	Overall budget balance, including grants (% of GDP in current USD from WDI (2003)).	World Bank, *WDI* (2003)
Inflation	Natural logarithm of 1+consumer price inflation rate.	World Bank, *WDI* (2003)
Openness (Sachs-Warner)	Dummy variable that measures the degree of openness.	Roodman (2004)
Institutional quality	ICRGE indicator: average of corruption, bureaucratic quality and rule of law indicators that take values between 0 and 10.	Roodman (2004)
Low-income countries	Dummy that takes the value 1 for low-income and low-middle-income countries.	World Bank