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Abstract

This paper develops a political economy model to analyze the direct and indirect effects of aid volatility on growth and the outcome of higher institutional quality on the effect of aid volatility on growth. Using time-series cross section data for 77 countries from 1984-2007, the effects of aid volatility on growth are empirically tested. It is concluded that the relationship between growth aid volatility is significantly negative and dependent on the level of institutional quality. The results are robust to additional covariates, alternate sub-samples, non-linearities, different period averages and various computations of aid volatility.

1. Introduction

Generally speaking, the rationale for foreign aid programs is that the provision of aid is beneficial to less developed countries (LDCs) because, among other things, it facilitates their economic growth and is thus welfare-improving. A substantial body of empirical literature systematically scrutinizing the link between aid provision and LDCs' economic growth rates now exists (e.g., Chatterjee and Turnovsky, 2007; Hansen and Tarp, 2000; Burnside and Dollar, 2000; Durbarry, Gemmell, and Greenaway, 1998; Dalgaard and Hansen, 2001; Lensink and White, 2001; Dalgaard et al., 2004; Guillaumont and Chauvet, 2001; Collier and Dehn, 2001). This wide-ranging body of literature has increased our understanding of donor allocation decisions, how aid affects LDCs' output, and the associated transmission mechanisms.

Most studies of foreign aid have attended to the question of whether aid facilitates or hinders economic growth in LDCs. Contradictory empirical answers to this question has more recently led to a focus on volatility in the disbursal of foreign aid and its impact on economic growth. Although research on aid volatility is a valuable advance on previous work, there has been scant attention paid to another potentially important factor that may affect an aid-recipient's output: the interactions between the potentially corrupt distributional behavior of a recipient government and institutional quality of the environment in which it operates.

This paper develops a formal model of foreign aid output-effects which integrates aid volatility, a recipient government's decision-making, and the quality of the institutional environment in which the government is embedded. Our model suggests that an aid-recipient government operating in a lower quality institutional environment is less constrained in its propensity to use aid for self-consumption ('corrupt' expenditure), while a government facing a higher quality institutional environment is more constrained in diverting aid to self-consumption. This model entails a finding consistent with most empirical aid volatility-output studies, namely, that for a given level of institutional quality, an increase in aid volatility is detrimental to the country's output (Fielding & Mavrotas, 2006; Lensink & Morrissey, 2000; Hudson & Mosley, 2008; Neandis & Varvarigos, 2007; Bulir & Hamann, 2008; Arellano et. al, 2009).

As an advance, our model shows that if institutional quality increases as aid volatility is increasing, the overall effect on output of the former depends on (a) relative changes in magnitude of a 'prudence effect' and a 'transparency effect' (The prudence effect is a direct effect of aid volatility on the government's decision to increase public and private capital while the transparency effect is the response of the government to a decrease in the institutional quality it is constrained by). (b) the direction of the transparency effect and (c) the relative magnitudes of increasing marginal benefits to the government and households of consumption.

In the empirical section of the paper, we test the following hypotheses arising out of the theoretical model: (i) Does aid volatility negatively affect economic growth when subjected to various computations of aid volatility? (ii) Does higher institutional quality faced by aid-recipient governments offset the total effect of aid volatility on growth?

2. Overview of literature on the effect of aid and volatility

Early theories of underdevelopment saw foreign aid as a means of escaping national poverty. For example, Nelson's (1956) Poverty Trap model held that a number of factors ranging from high populations, low savings rates and low tax bases resulted in self-reinforcing poverty and underdevelopment. Nelson suggested that a large exogenous injection of foreign aid could 'pump prime' economic growth. Chenery and Strout's (1966) Two Gap theory identified inadequate domestic savings and foreign exchange earnings as binding constraints on domestic LDC investment which curtailed potential growth. For them, foreign aid could play a key role in closing the savings or trade gaps, thereby stimulating growth and increasing future productive capacity. Both models still have currency today (e.g., Hansen and Tarp, 2001; Easterly, 1999, 2001; Chatterjee and Turnovsky, 2007; Kraay and Raddatz, 2007; Agenor and Aizenman, 2010).

Empirical studies of the relationship between foreign aid and economic growth has produced contradictory results. On one hand, some studies have found often suggested that aid had either negligible or negative effects on growth (e.g. Griffin, 1970; Griffin and Enos, 1970; Voivodas, 1973; Mosley, 1980; Dowling and Hiemenz, 1982; Mosley, Hudson and Horrell, 1987; Boone, 1994; Easterly, 1999, 2001; Kanbur, 2000). Mosley, et.al. (1987) acknowledged that some particular aid projects had been successful, however, suggesting a "micro-macro paradox". To explain the ineffectiveness of aid, some suggest, following Bauer (1972, 1991), that the problem lies with the resource allocation distortions due to aid or corrupt aid-recipient governments (e.g. Boone, 1994; Kanbur, 2000).

On the other hand, the above findings have been contested on a variety of methodological and empirical grounds, often resulting in the converse finding that there is a positive relationship between aid and economic growth (e.g. Papanek, 1973; Dowling and Hiemenz, 1983; Singh, 1985; Levy, 1988; Durbarry, Gemmell and Greenaway, 1998; Stern, 2002; Stiglitz, 2002; Clemens, Radelet and Bhavnani, 2004). A variety of reasons have been offered for the positive findings. These include that aid augments savings and enables the financing of private and public investment, and that aid increases productivity by improving health and education services as well as proving technology transfer. It has also been found that the positive relationship between aid and growth is contingent upon macroeconomic stability and policy effects (e.g. Fischer, 1991, 1993; Easterly, 1993; Hadjimichael, Ghura, Muhleisen, Nord and Ucer, 1995; Bleaney, 1996; Burnside and Dollar, 1997). In summary, these studies found that in the presence of stable inflation, conservative fiscal policy and financial liberalization, foreign aid was positively related to private investment and economic growth – at least up to a threshold aid/GDP ratio (Hadjimichael et.al., 1995). Durbarry, Gemmell, and Greenaway (1998) also found that, conditional on a stable macroeconomic policy regime in LDCs that were not exceedingly poor, aid had a positive impact on economic growth within lower and upper aid/GDP thresholds. They also noted that since aid was ineffective where aid/GDP was relatively low and in very poor LDCs, this may account for the negative findings of previous studies.

More recently, another factor thought to negatively impact on the effectiveness of aid is volatility in aid disbursements by donors (e.g. Lensink and Morrissey 2000; Pallage and Robe, 2001; Bulíř and Hamann, 2003, 2008; Bulíř and Lane, 2004; Fielding and Mavrotas 2006; Neandis and Varvarigos 2007; Bulíř and Hamann 2008, Hudson and Mosely, 2008; Arellano, Bulíř, Lane and Lipschitz, 2009). This literature generally finds that aid volatility has a negative impact on the effectiveness of aid in stimulating economic growth (however, see Chauvet and Guillaumont, 2004, 2009). Although this work represents a significant advance in our understanding of aid effectiveness, it tends to ignore the potential importance of the choices made by corrupt aid-recipient governments and the quality of the institutional environment in which those governments function. Selected examples from the literature that demonstrate this is the case follow.

Although Lensink and Morrissey's (2000) attribute an implicit role for the aid-recipient government, their conclusion – that aid volatility impacts growth negatively due to fiscal uncertainty – is fails to account for the different *types* of government behavior in the face of aid volatility. For example, it may be that volatile aid flows are irrelevant to unaccountable corrupt governments uninterested in the productive channeling of aid money. Indeed, it may be conjectured that faced with higher the volatility, unaccountable governments can more easily conceal corrupt unproductive expenditure than more accountable governments faced with the same volatility. Similarly, in seeking to show that the effect of aid volatility is a more important explanation of growth outcomes than the allocation of aid between productive and non-productive uses *per se*, Neanidis and Varvarigos (2007) ignore the possible role of different institutional environments in accounting for government behavior. This is partly because they implicitly assume that aid-funded government expenditure will always be productive. If, however, we instead posit an unaccountable corrupt government, then we can contemplate aid-funded government expenditure that is not used for productive purposes. Further, we could also posit differential distributive behavior by governments in the face of volatile aid disbursements. Augmenting previous work, Hudson and Mosley (2008) find that although the initial impact of both 'upside' (above trend) and 'downside' (below trend) aid shocks are detrimental to economic growth, some of the negative impact is subsequently reversed in the case of 'upside' shocks. As with Lensink and Morrissey (2000), however, Hudson and Mosley implicitly assume that aid-recipient governments seek to maximize economic growth. This need not be the case. The degree to which a government is corrupt combined with the quality of the accountability institutions it faces may vary, and thus may have variable effects on the way a government distributes aid in the face of 'upside' and 'downside' shocks, which in turn could impact on national output. Using an intertemporal two-sector general equilibrium model, Arellano, et.al. (2009) find that welfare-enhancing, even in the face of a declining traded goods sector and little effect on investment, because it is used mainly for private consumption. However, for LDCs with little access to international capital for consumption smoothing, aid shocks result in welfare-diminishing consumption volatility. Thus eliminating aid volatility and government disbursal of aid in a manner that insured against macro-shocks would be highly welfare-enhancing. This prescription again implicitly assumes, however, that the recipient government is not corrupt and/or faces strong accountability institutions which would ensure a welfare enhancing disbursal of aid.

It should be noted, however, that discussion of the institutional environment that aid-recipient governments face is certainly not absent from the aid literature (e.g. Burnside and Dollar, 2000; Collier and Dollar, 2002; Lahiri and Michaelowa, 2006; McGillivray, Feeny, Hermes and Lensink, 2006; Epstein and Gang, 2009). With respect to the issue of aid volatility, although less conspicuous, aid-recipient institutional quality has also not been ignored. For example, Fielding and Mavrotas (2006) speculate that weaker policy environments hinder aid absorption, where aid volatility is induced by weak institutions. Consequently, they hypothesize that higher institutional quality is associated with reduced aid volatility, with the underlying explanation being that recipients with higher institutional quality may be better able to maintain 'good working relationships' with donors. Their empirical results however, do not confirm this hypothesis: higher institutional quality is not necessarily associated with less aid volatility. This is one of the few empirical investigations of aid volatility that incorporates institutional quality. It will be noted however, that Fielding and Mavrotas only seek to examine the behavior of the donor with respect to the aid recipient's institutions. They do not seek to examine the possible subsequent effect on economic output of how the institutional environment shapes the aid-allocative behavior of recipient governments.

To bridge the gap between the findings of empirical studies which conclude that aid volatility has negative growth effects and those empirical studies which find strong institutions to have growth enhancing effects, Kathavate & Mallik (2012) formalized a simple political economy mechanism to delineate how aid volatility negatively impacts growth and how its impact is mitigated with better quality institutions. As such, it was the first paper of its kind (as far as I know) in the area of foreign aid volatility which formalized the political economy mechanism linking aid volatility to growth and the strength of institutions to aid volatility and output, and which empirically confirmed both phenomenon to a host of robustness tests. Utilizing the theoretical framework of Kathavate & Mallik (2012) in this paper I formalize aid volatility to have two types of effects on growth: i) an indirect effect of aid volatility on growth (termed the "transparency effect") and ii) a direct effect (termed "the prudence effect"). Both effects are shown to be tempered by higher institutional quality. Empirically, we test the total effect of aid volatility on growth and the mitigating impact that higher quality institutions have on this, subject to a variety of sensitivity tests which were lacking in Kathavate & Mallik (2012).

The remainder of the paper is organized as follows. Section 3 presents the model of government choice and shows how the negative effect of aid volatility on output is mitigated by rises in the level of institutional quality. In Section 4, we motivate our empirical analysis by characterizing the empirical strategy and data. Section 5 discusses the empirical evidence for 77 countries from a period of 1984-2007, supporting the main results of the model, and Section 6 concludes.

3. A Simple Model

The government receives foreign aid which it allocates for public infrastructure, k, and income transfers to households (or transfers, for short), T. It is assumed that both of these expenditures are exclusively financed by aid donations. Output is determined by $Y = Y(k, K) = k^{\eta} K^{1-\eta}$, where K and k are private infrastructure and public infrastructure, respectively, and η is the elasticity of output with respect to public infrastructure. The amount of aid received by the aid-recipient government is denoted by A.The amount of income that remains after the government has allocated for public infrastructure and transfers is $A - k - T$. Households apportion a part of the income transfer they receive into private infrastructure. The fraction of income transfers the households allocate to private infrastructure is denoted by φ. Thus, the amount of private investment allocated by households can be represented by $K = \varphi T$, where $0 \le \varphi \le 1$. Further, it is assumed that the economy's output is subject to the following relationships: $Y_k, Y_K > 0$ and $Y_{kk}, Y_{KK} < 0$.

Aid receipts are conceptualized as follows. Donations are stochastic such that $A = \begin{Bmatrix} p(x_0 + x) \\ (1-p)(x_0 - x) \end{Bmatrix}$, where p is the probability of receiving 'high' aid and $(1-p)$ the probability of receiving 'low' aid. x_0 is the amount of officially promised aid, and x acts as a measure of volatility. Without loss of generality let $p = 1/2$, which we denote by p.

The government consumes the amount $A-k-T$ and obtains utility $u(A-k-T)$, where u is an increasing and concave utility function. The third derivative of the government's utility function is assumed to be positive ($u''' > 0$). That is, the government is assumed to be a prudent agent (see Kimball 1990). The amount, $A-k-T$, is treated as representing self-consumption, or in other words, corrupt expenditure.[1] If the government invests k and makes income transfers to individuals of magnitude T, then the expected payoff from self-consumption is:

$$E[u(A-k-T)] = p_h\left[u(x_0+x-k-T)\right] + (1-p_h)\left[u(x_0-x-k-T)\right]$$

This expected payoff assumes that the magnitude of public infrastructure and income transfers is less than the amount of aid received. Since aid is the only source of income, public infrastructure and income transfers cannot be greater than the amount of aid. Specifically, we assume $A \geq k+T$. We also assume that $x_0 > x$. This ensures that, first, the expected payoff is not left indeterminate, since $x_0 = x$ implies the right hand side of the expected payoff, particularly $(1-p_h)\big(u(x_0-x-k-T)\big)$, becomes $(1-p_h)\big(u(-k-T)\big)$, and second, aid receipts are non-negative.

The government however, faces a trade-off between maximizing expected utility from consumption and decreasing its probability of being removed from office by the citizenry. It is assumed that the government can improve its chances of staying in office by increasing the nation-state's output and thereby improving the citizenry's welfare. (Note that for simplicity it is assumed throughout that population growth is zero, so we can speak of output rather than output per capita.) It is further stipulated that the government possesses a specific propensity for engaging in corrupt behavior (i.e. self-consumption). This is denoted by α. This propensity weights the trade-off between self-consumption and citizenry utility.

The government's propensity to engage in corrupt behavior is assumed to be negatively related to the nation-state's institutional quality – the latter being defined as the strength of 'checks and balances' on government decision-making such as corruption commissions, freedom and independence of the press, freedom and independence of universities, independence and impartiality of the judicial system, democratic accountability, clear property rights and so on. The government's propensity for corruption,

[1] Corrupt behaviour is characterized by bribery, vote-buying, bolstering public servant salaries, pork barrelling, corrupt campaign financing, etc.

α , is a function of institutional quality, z . The parameter z is determined by cultural, political, psychological factors, which are exogenous to the model. We denote $\alpha = \alpha(z)$, where $\alpha_z(z) < 0, \alpha_{zz}(z) > 0$.

Note that the government is modeled as a maximizing agent conceptually separate from but affected by the institutional environment in which it operates. Institutional quality is a cost to the incumbent government in that a higher level of institutional quality increases the chances of it losing office, and thus places a high opportunity cost of self-consumption expenditure.

Changes in the level of institutional quality affect the magnitude of the parameter α . The larger is z the larger is the constraint on the government to use aid for self-consumption. It is assumed that with more rigorous institutional oversight, a government's probability of loosing office rises, which therefore decreases the government's propensity to engage in self-consumption. On the other hand, the lower is z , the lower is the constraint on a government's self-consumption. Such weaker institutional oversight reduces the government's probability of loosing office, which in turn raises the government's propensity for self-corruption. Note that in situations of lower levels of institutional quality the incumbent government may be able to remain in office through corrupt means, such as bribery, rigging elections, military intervention, etc. – and by virtue of the fact that the general public will not be fully aware of the extent of the government's corrupt activities.

It is further assumed that higher aid volatility generates more uncertainty for institutions in predicting the level of aid money going to the government. This increased uncertainty makes it more difficult for the nation-state's institutions to detect and monitor the government's activities (e.g. corruption commissions are less able to accurately monitor government finances). Work by Kangoye (2011) seems to allude to this interaction. Thus, z is reduced due to increased uncertainty in corruption-detection, and hence, the level of institutional quality is lowered. This has the effect of increasing the government's propensity for corruption.

The government cares in part about its own consumption and in part for citizens' welfare. To the degree that the government is incorrupt, denoted by $1-\alpha(z)$, it derives utility from productive expenditure directed towards the citizenry's welfare. To the degree that the government is corrupt, denoted by $\alpha(z)$, it derives utility from self-consumption. The parameter $1-\alpha(z)$ represents the government's 'level of benevolence'.

Indeed, a self-interested government derives utility from its citizens' welfare in so far as it believes that increasing citizens' utility increases its own chances of incumbency. The parameter $1-\alpha(z)$ thus serves as a weight for the importance that the government attaches to the degree to which their incumbency chances depend on citizens' welfare. The greater the aid-recipient's institutional quality, the higher is the government's subjective probability estimate of losing office, and hence the greater (smaller) is the weight the government will attribute to its citizens' welfare (own expected utility). Conversely, the lower the institutional quality, the lower is the government's probability of losing office, and hence the smaller (greater) is the weight the government will attribute to its citizens' welfare (own expected utility).

The government must solve the following problem:

$$\max_{k,T}\{\left[1-\alpha(z)\right]\left[u^{p}\left(Y(k,\varpi)\right)\right]+\alpha(z)E\left[u(A-k-T)\right]\} \tag{1}$$

$$=\max_{k,T}\{\left[1-\alpha(z)\right]\left[u^{p}\left(Y(k,\varphi T)+(1-\varphi)T\right)\right]+\alpha(z)\left[p\left(u(x_0+x-k-T)\right)+(1-p)\left(u(x_0-x-k-T)\right)\right]\}$$

$$\max_{k,T}\{\left[1-\alpha(z)\right]\left[u^{p}\left(Y(k,\varphi T)+(1-\varphi)T\right)\right]+\alpha(z)\left[p\left(u(x_0+x-k-T)\right)+(1-p)\left(u(x_0-x-k-T)\right)\right]\} \tag{2}$$

where $u^{p}\left(Y(k,\varphi T)+(1-\varphi)T\right)$ is the utility of the citizenry and is a function of household consumption, which is increasing in output, $Y(k,\varphi T$ and in the fraction of transfers which are consumed, $(1-\varphi)T$.) It is assumed that the citizens' utility function is concave in all arguments. The expected utility function for the government's self consumption is given by $E[u(A-k-T)]$. (Note: u^{p} is the utility of the citizenry, while u is the utility of the government.) Also, $0\leq\alpha(z)\leq 1$ is interpreted as the propensity for government engaging in self-consumption. The propensity for corruption, $\alpha(z)$, weighs the trade-off between the welfare of the people and the government's self-consumption. The closer $\alpha(z)$ is to 1, the greater is the government's propensity for self-consumption and conversely, the closer $\alpha(z)$ is to 0, the smaller is the government's propensity for self-consumption. It is assumed that the utility gained by the government through increasing citizenry utility is greater than the disutility experienced by the government from decreasing self-consumption in order to facilitate the increase in citizenry utility. This assumption is premised on the notion that the government wishes to enjoy future self-consumption, which requires it to retain office, and hence, one unit of increase in public capital expenditure generates greater utility through the citizenry utility function than disutility through its self-consumption function (i.e. $u_k^p>|u_k|$)

The first-order condition for the government's problem reveals that the optimal choices of k and T , satisfy the following first order conditions (optimized variables being asterisked):

$$\left[1-\alpha(z)\right]Y_k(k^*,\varphi T)\left[u_k^p\left(Y(k^*,\varphi T)+(1-\varphi)T\right)\right]$$

$$=\alpha(z)\left[p\left(u_k(x_0+x-k^*-T)\right)+(1-p)\left(u_k(x_0-x-k^*-T)\right)\right] \tag{3}$$

$$[1-\alpha(z)]\Big[\big(\varphi Y_T(k,\varphi T^*)+(1-\varphi)\big)u_T^p\big(Y(k,\varphi T^*)+(1-\varphi)T^*\big)\Big]$$
$$=\alpha(z)\Big[p\big(u_T(x_0+x-k-T^*)\big)+(1-p)\big(u_T(x_0-x-k-T^*)\big)\Big] \tag{4}$$

Re-arranging (3) and (4) we obtain,

$$\frac{\alpha(z)}{[1-\alpha(z)]}=\frac{Y_k(k^*,\varphi T)\Big[u_k^p\big(Y(k^*,\varphi T)+(1-\varphi)T\big)\Big]}{\Big[p\big(u_k(x_0+x-k-T^*)\big)+(1-p)\big(u_k(x_0-x-k-T^*)\big)\Big]} \tag{5}$$

$$\frac{\alpha(z)}{[1-\alpha(z)]}=\frac{\Big[\big(\varphi Y_T(k,\varphi T^*)+(1-\varphi)\big)u_T^p\big(Y(k,\varphi T^*)+(1-\varphi)T^*\big)\Big]}{\Big[p\big(u_T(x_0+x-k-T^*)\big)+(1-p)\big(u_T(x_0-x-k-T^*)\big)\Big]} \tag{6}$$

The L.H.S of equation (5) is a proxy for the propensity for government self-consumption (since the L.H.S is increasing in $\alpha(z)$). Thus, equation (5) expresses the propensity of government self-consumption as an implicit function of the marginal utility functions of the government with respect to capital for 'high' and 'low' levels of foreign aid and the marginal utility of the citizenry with respect to capital public infrastructure. Equation (6) expresses the propensity of government self-consumption as an implicit function of the marginal utility functions of the government with respect to income transfers for 'high' and 'low' foreign aid and the marginal utility of the citizenry with respect to income transfers.

Proposition 1

P1: As aid volatility (x) increases, the government's optimal public infrastructure (k^*) and optimal transfer payments (T^*) decrease.

Proof:

Taking the total differential of public infrastructure with respect to aid volatility, x, yields:

$$dk^*=\frac{\partial k^*}{\partial x}dx+\frac{\partial k^*}{\partial z}dz$$
$$\frac{dk^*}{dx}=\frac{\partial k^*}{\partial x}+\frac{\partial k^*}{\partial z}\frac{dz}{dx}$$

For equation (3) using the implicit function theorem, the partial derivative of optimal public infrastructure with respect to aid volatility $\frac{\partial k^*}{\partial x}$, is:

$$\frac{\partial k^*}{\partial x} = \frac{-\left[p\left(u_{kk}(C_k^H)\right)+(p-1)\left(u_{kk}(C_k^L)\right)\right]}{-\left[p\left(u_{kk}(C_k^L)\right)-(p-1)\left(u_{kk}(C_k^H)\right)\right]+\left\{-\frac{[1-\alpha(z)]}{\alpha(z)}\begin{bmatrix} Y_{kk}(k^*,\varphi T)\left[u_k^p\left(Y(k^*,\varphi T)+(1-\varphi)T\right)\right] \\ +\left(Y_k(k^*,\varphi T)\right)^2\left[u_{kk}^p\left(Y(k^*,\varphi T)+(1-\varphi)T\right)\right]\end{bmatrix}\right\}} \tag{7}$$

where, $C_k^H \equiv x_0 + x - k^* - T$ and $C_k^L \equiv x_0 - x - k^* - T$; C represents consumption which remains post allocation of optimal public infrastructure expenditure; the superscripts refer to 'low' aid (L) and 'high' aid (H) while the subscripts denote the implicitly differentiated variable with respect to volatility.

For equation (2), using the implicit function theorem, the partial derivative of optimal public infrastructure with respect to the nation-state's institutional quality, $\frac{\partial k^*}{\partial z}$, is:

$$\frac{\partial k^*}{\partial z} = \frac{\alpha_z(z)\left\{\left[p\left(u_k(C_k^H)\right)+(1-p)\left(u_k(C_k^L)\right)\right]+Y_k\left[u_k^p(Y+(1-\varphi)T\right]\right\}}{[1-\alpha(z)]\begin{bmatrix} Y_{kk}\left(u_k^p(Y+(1-\varphi)T)\right) \\ +\left(Y_k\right)^2\left(u_{kk}^p(Y+(1-\varphi)T)\right)\end{bmatrix}+\alpha(z)\left[p\left(u_{kk}(C_k^H)\right)+(1-p)\left(u_{kk}(C_k^L)\right)\right]} \tag{8}$$

where $\alpha_z(z)$ is the derivative of the government's inherent level of corruption with respect to the institutional quality

The total derivative for optimal public infrastructure with respect to aid volatility is:

$$\frac{dk^*}{dx} = \left[\frac{-\left[p_h\left(u_{kk}(C_k^H)\right) + (p_h - 1)\left(u_{kk}(C_k^L)\right)\right]}{-\left[p_h\left(u_{kk}(C_k^L)\right) - (p_h - 1)\left(u_{kk}(C_k^H)\right)\right]_x + \left\{ -\frac{\alpha(z)}{\left[1-\alpha(z)\right]} \Psi_k^x \right\}} \right]$$

$$+ \left[\frac{\left\{ \left[p_h\left(u_k(C_k^H)\right) + (1-p_h)u_k(C_k^L)\right] + Y_k\left[u_k^p(Y + (1-\varphi)T)\right]\right\}}{\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\left[p_h\left(u_{kk}(C_k^H)\right) + (1-p_h)\left(u_{kk}(C_k^L)\right)\right]} \right] \left[\alpha_z(z)\frac{dz}{dx} \right] \tag{9}$$

where $\Psi_k^x = \begin{bmatrix} Y_{kk}(k^*, \varphi T)\left[u_k^p\left(Y(k^*, \varphi T) + (1-\varphi)T\right)\right] \\ +\left(Y_k(k^*, \varphi T)\right)^2\left[u_{kk}^p\left(Y(k^*, \varphi T) + (1-\varphi)T\right)\right] \end{bmatrix}$; $\left[u_{kk}(C_k^L) + u_{kk}(C_k^H)\right]_x$ denotes the second derivative of the government's utility function with respect to optimal public infrastructure as aid volatility increases, while $\left[\frac{1}{2}u_{kk}(C_k^H) + \frac{1}{2}u_{kk}(C_k^L)\right]_{\alpha(z)}$ represents the second derivative of the government's utility function with respect to optimal public infrastructure as institutional quality increases.

Similarly, taking the total differential of transfers with respect to aid volatility, x, yields:

$$dT^* = \frac{\partial T^*}{\partial x}dx + \frac{\partial T^*}{\partial z}dz$$
$$\frac{dT^*}{dx} = \frac{\partial T^*}{\partial x} + \frac{\partial T^*}{\partial z}\frac{dz}{dx}$$

For equation (4) using the implicit function theorem, the partial derivative of optimal income transfers with respect to aid volatility $\frac{\partial T^*}{\partial x}$, is:

$$\frac{\partial T^*}{\partial x} = \frac{p\left(u_{TT}(C_T^H)\right) + (p-1)\left(u_{TT}(C_T^L)\right)}{\left(\frac{\left[1-\alpha(z)\right]}{\alpha(z)} \begin{bmatrix} \varphi Y_{TT}(k, \varphi T^*)\left[u_T^p\left(Y(k, \varphi T^*) + (1-\varphi)T^*\right)\right] \\ +\left(\varphi Y_T(k, \varphi T^*) + (1-\varphi)\right)^2\left[u_{TT}^p\left(Y(k, \varphi T^*) + (1-\varphi)T^*\right)\right] \end{bmatrix} + p\left(u_{TT}(C_T^H)\right) - (p-1)\left(u_{TT}(C_T^L)\right) \right)} \tag{10}$$

where, $C_T^H \equiv x_0 + x - k - T^*$ and $C_T^L \equiv x_0 - x - k - T^*$; C represents consumption which remains post allocation of optimal income transfers expenditure; the superscripts refer to 'low' aid (L) and 'high' aid (H) while the subscripts denote the implicitly differentiated variable with respect to volatility.

For equation (4), using the implicit function theorem, the partial derivative of income transfers with respect to the nation-state's institutional quality $\frac{\partial T^*}{\partial z}$, is:

$$\frac{\partial T^*}{\partial z} = \frac{\alpha_z(z)\Big[\big[p\big(u_T(C_T^H)\big)+(1-p)\big(u_T(C_T^L)\big)\big]+Y_T(k,\varphi T^*,H)\big[u_T^p(Y(k,\varphi T^*,H))+(1-\varphi)T^*\big]\Big]}{[1-\alpha(z)]\begin{bmatrix}\varphi^2 Y_{TT}(k,\varphi T^*)\big(u_T^p(Y(k,\varphi T^*))+(1-\varphi)T^*)\big) \\ +\big(\varphi Y_T(k,\varphi T^*)+(1-\varphi)\big)\varphi Y_T(k,\varphi T^*)\big(u_{TT}^p(Y(k,\varphi T^*)+(1-\varphi)T^*)\big)\end{bmatrix}+\alpha(z)\big[p\big(u_{TT}(C_T^H)\big)+(1-p)\big(u_{TT}(C_T^L)\big)\big]} \quad (11)$$

where $\alpha_z(z)$ is the derivative of the government's inherent level of corruption with respect to the institutional quality

The total derivative for optimal income transfers with respect to aid volatility is:

$$\frac{dT^*}{dx} = \frac{-\big[p\big(u_{TT}(C_T^H)\big)+(p-1)\big(u_{TT}(C_T^L)\big)\big]}{-\big[p\big(u_{TT}(C_T^H)\big)-(p-1)\big(u_{TT}(C_T^L)\big)\big]_x+\left\{-\frac{[1-\alpha(z)]}{\alpha(z)}\Psi_T^x\right\}}$$
$$+\frac{\big[p\big(u_T(C_T^H)\big)+(1-p)\big(u_T(C_T^L)\big)\big]+Y_T\big[u_T^p(Y+(1-\varphi)T^*)\big]}{[1-\alpha(z)]\Psi_T^x+\alpha(z)\big[p\big(u_{TT}(C_T^H)\big)+(1-p)\big(u_{TT}(C_T^L)\big)\big]}\left[\alpha_z(z)\frac{dz}{dx}\right] \quad (12)$$

where $\Psi_T^x = \begin{bmatrix}\varphi^2 Y_{TT}\big(u_T^p(Y+(1-\varphi)T^*)\big) \\ +\big(\varphi Y_T+(1-\varphi)\big)\varphi Y_T\big(u_{TT}^p(Y+(1-\varphi)T^*)\big)\end{bmatrix}$; $\big[p\big(u_{TT}(C_T^H)\big)-(p-1)\big(u_{TT}(C_T^L)\big)\big]_x$ represents the second derivative of the government's utility function with respect to optimal income transfers as aid volatility increases, while $\big[p\big(u_{TT}(C_T^H)\big)+(1-p)\big(u_{TT}(C_T^L)\big)\big]_{\alpha(z)}$ represents the second derivative of the government's utility function with respect to optimal transfers as institutional quality increases.

Assuming a prudent government, i.e. $u_{kk}(C_k^H) > u_{kk}(C_k^L), u_{TT}(C_T^H) > u_{TT}(C_T^L)$, given the concavity of the government's utility, $\left[p\left(u_{kk}(C_k^H)\right)-(p-1)\left(u_{kk}(C_k^L)\right)\right]_x, \left[p\left(u_{TT}(C_T^H)\right)-(p-1)\left(u_{TT}(C_T^L)\right)\right]_x < 0$, given the government's preference $u_k^p > |u_k|$, and noting that $\Psi_k^x, \Psi_T^x < 0$, we can conclude that the left hand side of equations (7) and (8) is negative.

Additionally, since $\left[p\left(u_k(C_k^H)\right)+(1-p)u_k(C_k^L)\right]+Y_k\left[u_k^p(Y+(1-\varphi)T)\right]$,

$\left[p\left(u_T(C_T^H)\right)+(1-p)\left(u_T(C_T^L)\right)\right]+Y_T\left[u_T^p(Y+(1-\varphi)T^*)\right], \alpha_z(z)\dfrac{dz}{dx} > 0$,

$\left[p\left(u_{kk}(C_k^H)\right)+(1-p)\left(u_{kk}(C_k^L)\right)\right]_{\alpha(z)}, \left[p\left(u_{TT}(C_T^H)\right)+(1-p)\left(u_{TT}(C_T^L)\right)\right]_{\alpha(z)} > 0$ and $\Psi_k^x, \Psi_k^{\alpha(z)}, \Psi_T^x, \Psi_T^{\alpha(z)} < 0$, we conclude $\dfrac{dk^*}{dx}, \dfrac{dT^*}{dx} < 0$.

■

Intuition: Higher aid volatility implies greater variation (amplitude) in potential aid donations, and thus increased uncertainty regarding aid receipts. Given the nation-state's level of institutional quality, the government reacts to higher aid volatility by increasing its stock of savings by diverting some aid money from public investment/transfers in order to smooth its consumption expenditure in the future. The stock of savings is conceptualized as a part of future consumption expenditure or delayed consumption expenditure. This reaction by the government to a rise in the aid volatility is termed the 'prudence effect'.

Further, higher aid volatility makes it more difficult for a nation-state's institutions to detect the government's corrupt practices than otherwise would be the case (in other words, higher aid volatility makes it is easier for the government to conceal its corrupt activities). Thus, increases in aid volatility are followed by decreases in the institutional quality, which impel increases in the government's propensity for self-consumption. Increases in the propensity for corruption, drive down the optimal level of infrastructure and income transfer expenditure. This reaction of the government is termed the 'transparency effect'.

It is assumed that the government needs to remain in office in order to consume aid money for itself. Though a trade-off between self-consumption and productive consumption (i.e. infrastructure for the sake of the citizenry) exists, by increasing self-consumption expenditure and scaling down infrastructure expenditure, the government does not necessarily harm its chances of reelection. The reason is as follows i) Firstly, the government's scaling down of infrastructure expenditure seems consistent to the citizenry with the expected behavior of a government under conditions of aid volatility; For the citizenry, the expected behavior of a government when faced with increasing aid volatility is as follows: with respect to public infrastructure, since higher aid volatility implies greater variation of potential aid donations (and hence increased uncertainty of aid), the citizenry finds it reasonable to expect a government facing aid volatility to moderate its public infrastructure so that small scale projects can be completed in a given (high aid) period, or if aid in a following period is low, the smaller scale projects can continue or be completed. This is to be contrasted with the alternative: if, in the face of high aid volatility, a government persisted with larger long-term public infrastructure plans, this would render the infrastructure of large scale projects taking on a ‘start-stop’ character, which would be unpopular. Furthermore, assuming private and public infrastructure complementarities, a government would moderate public infrastructure so as to not indirectly generate volatility for private infrastructure, which would be partly dependent on the completion of public infrastructure projects. With respect to income transfers, since higher aid volatility implies greater variation of potential aid donations (and thus more income uncertainty), it would be reasonable to expect a government facing aid volatility to moderate its income transfers in such a way that uncertainty for private spending and infrastructure is minimized.

Proposition 2

P2: The overall effect on optimal public infrastructure and optimal transfers of an increase in the institutional quality combined with an increase in aid volatility is partly conditioned by the government’s relative increases in diminishing marginal utility of its self-consumption versus citizenry utility:

i) *If the following inequalities hold:* $\left|u^{p}_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$ *and* $\left|u^{p}_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$, *then the negative impact of aid volatility on optimal public capital infrastructure (* k^*_x *) and optimal income transfers (* T^*_x *) is offset as institutional quality increases.*

ii) *If the following inequalities hold:* $\left|u^{p}_{k^*k^*}\right| < \left|u_{k^*k^*}\right|$, $\left|u^{p}_{T^*T^*}\right| < \left|u_{T^*T^*}\right|$, *then whether the negative impact of aid volatility on optimal public capital infrastructure (* k^*_x *) and optimal income transfers (* T^*_x *) is exacerbated or offset as institutional quality increases is contingent on the direction of the transparency effect as well as the relative magnitudes of the prudence and transparency effects.*

Proof:

For notational ease let

$$\left[p\left(u_{kk}(C^H_k)\right)+(p-1)\left(u_{kk}(C^L_k)\right)\right]=\Phi_k;\ \left[p\left(u_{kk}(C^L_k)\right)-(p-1)\left(u_{kk}(C^H_k)\right)\right]_x=\Gamma^x_k;\left[p\left(u_{kk}(C^L_k)\right)+(1-p)\left(u_{kk}(C^H_k)\right)\right]_{\alpha(z)}=\Gamma^{\alpha(z)}_k$$

$$;\left[p\left(u_k(C^H_k)\right)+(1-p)\left(u_k(C^L_k)\right)\right]=\Omega_k \text{ and } Y_k\left[u^p_k(Y+(1-\varphi)T)\right]=Y_k u^p_k$$

Equation (9) can be re-written as:

$$k_x^* = \frac{-\Phi_k}{-\Gamma_k^x - \dfrac{2\left[1-\alpha(z)\right]}{\alpha(z)}\Psi_k^x} + \frac{\Omega_k + Y_k u_k^p}{\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\Gamma_k^{\alpha(z)}}\left[\alpha_z(z)\left(dz/dx\right)\ \right] \tag{13}$$

Differentiating with respect to the institutional quality z, we obtain:

$$\left(dk^*/dx\right)_z = \frac{2\alpha_z(z)\Phi_k\Psi_k}{\left[-\Gamma_k^x - \left(\dfrac{2\left[1-\alpha(z)\right]}{\alpha(z)}\right)\Psi_k^x\right]^2\left[\alpha(z)\right]^2} + \frac{\left(\Omega_k + Y_k u_k^p\right)\left[\Psi_k^x - \Gamma_k^{\alpha(z)}\right]}{\left[\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\Gamma_k^{\alpha(z)}\right]^2}\left[\alpha_z(z)\left(dz/dx\right)\right]$$

$$+\frac{\Omega_k + Y_k u_k^p}{\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\Gamma_k^{\alpha(z)}}\left[\alpha_{zz}(z)\left(dz/dx\right)\right] \tag{14}$$

where,

$$\left(dk^*/dx\right)_z > 0 \ \text{ if } \ \frac{\left(\Omega_k + Y_k u_k^p\right)\left[\Psi_k^x - \Gamma_k^{\alpha(z)}\right]}{\left[\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\Gamma_k^{\alpha(z)}\right]^2} \geq 0$$

and $\dfrac{\left(\Omega_k + Y_k u_k^p\right)\left[\Psi_k^x - \Gamma_k^{\alpha(z)}\right]}{\left[\left[1-\alpha(z)\right]\Psi_k^x + \alpha(z)\Gamma_k^{\alpha(z)}\right]^2} \geq 0$ implies $\left|\Psi_k^x\right| \geq \left|\Gamma_k^{\alpha(z)}\right|$

where, $\Psi_k^x = \begin{bmatrix} Y_{kk}\left(u_k^p(Y + (1-\varphi)T)\right) \\ +\left(Y_k\right)^2\left(u_{kk}^p(Y + (1-\varphi)T)\right) \end{bmatrix}$ and $\Gamma_k^{\alpha(z)} = \left[p\left(u_{kk}(C_k^L)\right) + (1-p)\left(u_{kk}(C_k^H)\right)\right]$

In order to establish interpretable propositions, it is necessary to transform the above inequality. For this purpose, we can re-write equation (3) as follows:

$\left[1-\alpha(z)\right]u_{k^*}^p - \alpha(z)u_{k^*} = 0$,

where $u_{k^*}^p = Y_k(k^*, \varphi T)\left[u_k^p\left(Y(k^*, \varphi T) + (1-\varphi)T\right)\right]$ and $u_{k^*} = \left[p\left(u_k(x_0 + x - k^* - T)\right) + (1-p)\left(u_k(x_0 - x - k^* - T)\right)\right] = 0$

We can also re-write equation (8) in terms of k_z^*, $u_{k^*k^*}^p$ and $u_{k^*k^*}$,

$-\alpha_z(z)u_{k^*}^p + \left[1-\alpha(z)\right]k_z^* u_{k^*k^*}^p - \left(\alpha_z(z)u_{k^*} + \alpha(z)k_z^* u_{k^*k^*}\right) = 0$

where, $k_z^* u_{k^*k^*}^p = k_z^*\left[Y_{kk}\left(u_k^p(Y + (1-\varphi)T)\right) + \left(Y_k\right)^2\left(u_{kk}^p(Y + (1-\varphi)T)\right)\right]$ and

$k_z^* u_{k^*k^*} = k_z^*\left[p\left(u_{kk}(C_k^H)\right) + (1-p)\left(u_{kk}(C_k^L)\right)\right]_{\alpha(z)}$

We can now re-express $\left|\Psi_k^x\right| \geq \left|\Gamma_k^{\alpha(z)}\right|$

$$\left\|\left[Y_{kk}\left(u_k^p(Y+(1-\varphi)T)\right)+\left(Y_k\right)^2\left(u_{kk}^p(Y+(1-\varphi)T)\right)\right]\right\| \geq$$

or $$\left\|\left[p\left(u_{kk}(C_k^H)\right)+(1-p)\left(u_{kk}(C_k^L)\right)\right]\right\|$$

is $\left|u_{k^*k^*}^p\right| \geq \left|u_{k^*k^*}\right|$

From the total derivative equation for optimal public infrastructure, we let $k_{xz}^* = \pi_k$, and $\left(k_z^*\left(dz/dx\right)\right)_z = \Phi_k$, where subscript k denotes the impact of increase in the nation-state's institutional quality on the prudence and transparency effects respectively at the level of optimal public infrastructure. We thus classify the effect of an increase in institutional quality on $\left(dk^*/dx\right)$ into two cases:

<u>Case 1:</u> For $\left|u_{k^*k^*}^p\right| \geq \left|u_{k^*k^*}\right|$, $\left(dk^*/dx\right)_z > 0$ since $\Phi_k > 0,\ \pi_k > 0$.

<u>Case 2:</u> For $\left|u_{k^*k^*}^p\right| < \left|u_{k^*k^*}\right|$: $\left(dk^*/dx\right)_z \begin{Bmatrix} >0 \text{ for } \Phi_k < 0, \left|\pi_k\right| > \left|\Phi_k\right| \\ <0 \text{ for } \Phi_k < 0, \left|\pi_k\right| < \left|\Phi_k\right| \\ >0 \text{ for } \Phi_k > 0 \end{Bmatrix}$

Performing similar calculations for optimal transfers yields two cases:

<u>Case 1:</u> For $\left|u_{T^*T^*}^p\right| \geq \left|u_{T^*T^*}\right|$, $\left(dT^*/dx\right)_z > 0$ since $\Phi_T > 0,\ \pi_T > 0$.

<u>Case 2:</u> For $\left|u_{T^*T^*}^p\right| < \left|u_{T^*T^*}\right|$: $\left(dT^*/dx\right)_z \begin{Bmatrix} >0 \text{ for } \Phi_T < 0, \left|\pi_T\right| > \left|\Phi_T\right| \\ <0 \text{ for } \Phi_T < 0, \left|\pi_T\right| < \left|\Phi_T\right| \\ >0 \text{ for } \Phi_T > 0 \end{Bmatrix}$

where the subscript T denotes the impact of increase in the nation-state's institutional quality on prudence and transparency effects at the level of optimal public infrastructure.

■

In the discussion of proposition 1 we conjectured that given the institutional quality of the nation-state, an increase in aid volatility impels the government to raise its level of savings (i.e. its delayed consumption expenditure). For proposition 2, we conjecture that when increased aid volatility is *combined* with increased institutional quality, the government decreases its stock of savings. This is because greater institutional quality provides a lesser opportunity for a corrupt government to further misappropriate aid. In an environment in which greater checks and balances exist on the government's activities, potential misappropriated aid is now redirected to public infrastructure. As a consequence, the negative marginal effect of a rise in aid volatility on optimal infrastructure and optimal transfers is offset as institutional quality increases.

The overall effect on optimal public infrastructure and income transfers, however, of an increase in the institutional quality depends on whether $\left|u^{p}_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$ and $\left|u^{p}_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$, the direction of the transparency effect (denoted above by the following possibilities, $\Phi_k \overset{>}{\underset{<}{-}} 0$, $\Phi_T \overset{>}{\underset{<}{-}} 0$), and its relative magnitude with respect to the prudence effect (denoted above by the following possibilities, $\left|\pi_k\right| > \left|\Phi_k\right|, \left|\pi_k\right| < \left|\Phi_k\right|$, $\left|\pi_T\right| > \left|\Phi_T\right|, \left|\pi_T\right| < \left|\Phi_T\right|$).

The rationale for $\left|u^{p}_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$, $\left|u^{p}_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$ is as follows. If the government faces an increase in the institutional quality, this change in conditions gives rise to its re-evaluation of its public infrastructure and transfers expenditure. It is posited here that this re-evaluation is based on a 'benchmark' – viz. a comparison by the government of its increasing marginal benefits relative to the decreasing marginal benefits of households. The government's rule for the inequality in case 1 (the inequality in case 2) is: for any increase in public infrastructure/transfers, whenever the magnitude of decreases in the households' marginal utility are smaller than or equal to (greater) its own magnitude of increases in its marginal disutility, the government increases public infrastructure to a greater (smaller) degree at the margin, than in the case where its magnitude of increasing marginal disutility were smaller than the magnitude of decreasing marginal utility experienced by households. This rule is based on the premise that the government is less (more) confident about its incumbency chances at the margin, since the threat of losing office is perceived to be higher (lower). Thus, the government feels incentivized at the margin to increase public infrastructure and transfers to greater (smaller) degrees in the belief that such a decision will enable them to retain office and enjoy future self-consumption.

The overall effect on optimal public infrastructure and optimal transfers in the first case is positive. The overall effect on optimal public infrastructure and optimal transfers in the second case depends on the direction of change in the transparency effect and the relative magnitude of the transparency effect in comparison to the prudence effect. If the response of the transparency effect is negative, then the negative impact of aid volatility on public infrastructure and transfers is offset if and only if the magnitude of the prudence effect is greater than the magnitude of the transparency effect. If the response of the transparency effect is in the positive direction, then the impact of aid volatility on public infrastructure and transfers is unconditionally offset.

Proposition 3

Given propositions 1 and 2, output (Y) is negatively related to volatility (x).

Proof:

Recall the assumptions of the model $Y_k, Y_K > 0$, which denote that output is increasing (decreasing) as public investment and private investment increases (decreases).

Noting that optimal private investment is a function of income transfers, $K^* = \varphi T^*$, the result of proposition 1, namely $\frac{dT^*}{dx} < 0$, implies $\frac{dK^*}{dx} < 0$.

Thus we conclude that optimal output is negatively related to aid volatility $\frac{dY^*}{dx} < 0$, via its negative impact on optimal public and private investment.

■

The explanation for this relationship is now well established in the literature.

Proposition 4

The overall effect on output of an increase in the institutional quality combined with an increase in aid volatility is partly conditioned by the government's relative increases in diminishing marginal utility of its self-consumption versus citizenry utility: $\left|u^p_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$ *and* $\left|u^p_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$.

i) *If the following inequalities hold:* $\left|u^p_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|, \left|u^p_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$, *then the negative impact of aid volatility on output is offset as institutional quality increases.*

ii) *If the following inequalities hold:* $\left|u^p_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|$, $\left|u^p_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$, *then whether the negative impact of aid volatility on output is exacerbated or offset as institutional quality increases is contingent on the direction of the transparency effect as well as the relative magnitudes of the prudence and transparency effects.*

Proof:

Proof of the 2nd order mixed partial derivative inequalities was given above (see proof for proposition 2.)

<u>Case 1:</u> $\left|u^p_{k^*k^*}\right| \geq \left|u_{k^*k^*}\right|, \left|u^p_{T^*T^*}\right| \geq \left|u_{T^*T^*}\right|$

Since $\frac{\partial}{\partial z}\frac{dk^*}{dx} < 0$ and noting that since $K^* = \varphi T^*$, $\frac{\partial}{\partial z}\frac{dT^*}{dx} < 0$ implies $\frac{\partial}{\partial z}\frac{dK^*}{dx} < 0$, $\frac{\partial}{\partial z}\frac{dY}{dx} < 0$ follows from the assumption $Y_k, Y_K > 0$.

Thus we conclude that the effect of a rise in institutional quality on the negative marginal impact of aid volatility on optimal output is offset via its mitigatory effect on optimal public and private investment, $\frac{\partial}{\partial z}\frac{dY^*}{dx} > 0$.

Case 2: $\left|u^p_{k^*k^*}\right| < \left|u_{k^*k^*}\right|$, $\left|u^p_{T^*T^*}\right| < \left|u_{T^*T^*}\right|$

Since the overall impact of aid volatility on optimal public investment and income transfers is given by the following set of inequalities:

$$\frac{\partial\left(dk^*/dx\right)}{\partial z}\begin{Bmatrix} >0 \text{ for } \Phi_k < 0, \left|\pi_k\right| > \left|\Phi_k\right| \\ <0 \text{ for } \Phi_k < 0, \left|\pi_k\right| < \left|\Phi_k\right| \\ >0 \text{ for } \Phi_k > 0 \end{Bmatrix} \quad \frac{\partial\left(dT^*/dx\right)}{\partial z}\begin{Bmatrix} >0 \text{ for } \Phi_T < 0, \left|\pi_T\right| > \left|\Phi_T\right| \\ <0 \text{ for } \Phi_T < 0, \left|\pi_T\right| < \left|\Phi_T\right| \\ >0 \text{ for } \Phi_T > 0 \end{Bmatrix}$$, where the latter sets of inequalities

imply that the effect of aid volatility on optimal public investment is shaped by the following combinations of outcome:

$$\frac{\partial\left(dK^*/dx\right)}{\partial z}\begin{Bmatrix} >0 \text{ for } \Phi_K < 0, \left|\pi_K\right| > \left|\Phi_K\right| \\ <0 \text{ for } \Phi_K < 0, \left|\pi_K\right| < \left|\Phi_K\right| \\ >0 \text{ for } \Phi_K > 0 \end{Bmatrix}.$$

Based on the assumption, $Y_k, Y_K > 0$, the effect of an increase in institutional quality on the impact of aid volatility on optimal output follows the following sets of inequalities:

$$\frac{\partial\left(dY^*/dx\right)}{\partial z}\begin{Bmatrix} >0 \text{ for } \Phi_Y < 0, \left|\pi_Y\right| > \left|\Phi_Y\right| \\ <0 \text{ for } \Phi_Y < 0, \left|\pi_Y\right| < \left|\Phi_Y\right| \\ >0 \text{ for } \Phi_Y > 0 \end{Bmatrix}$$, where the subscript Y denotes the impact of increase in the nation-state's institutional quality on prudence and transparency effects at the level of optimal public investment.

■

Proposition 4 is an implication of the formal combination of the previously demonstrated propositions. Thus, the explanations of the previous propositions mutatis mutandis apply.

4. Empirical Strategy and Data:

We utilize panel data which covers 77 countries over the period of 1984-2007. To test our propositions outlined in the theoretical section, we employ the following model:

$$y_{irt} = \alpha_r + \beta_t + \gamma_1 z_{irt} + \gamma_2 v_{irt} + \gamma_3 (z_{irt} \times v_{irt}) + \sum_{j=1}^{k} \delta_j X'_{irt} + \varepsilon_{irt} \tag{15}$$

where y_{irt} is average annual growth per capital GDP in country i in region r averaged over $t-2$ years to t[2], α_r is a regional dummy variable for four regions of the world, which controls for regional fixed effects, β_t is a variable capturing time varying shocks, z_{irt} is a measure of the nation-state's institutional quality in country i in region r averaged over $t-2$ years to t, v_{irt} is a measure of aid volatility in country i in region r averaged over $t-2$ years to t, $(z_{irt} \times v_{irt})$ is a measure of the interaction between a nation-state's institutional quality and aid volatility in country i in region r averaged over $t-2$ years to t and X'_{irt} is a vector of various control variables.

Taking the derivative of the equation above with respect to volatility yields the following point estimate: $\gamma_2 + \gamma_3 z_{irt}$. Our analysis focuses on the coefficients, γ_2 and γ_3. Our theoretical section suggests that γ_2 should be significantly negative and γ_3 should be significantly positive. This implies that z_{irt} has a threshold below which the effect of aid volatility on growth is negative and above which the effect is positive.

Data on institutional is collected from the International Country Risk Guide (ICRG) database[34]. Institutional quality is constructed as a composite measure of democratic accountability, institutional corruption and political rights. The ICRG measure of democratic accountability measures the degree to which the nation-state's institutions: i) are accountable to the public; iii) have the ability to conduct free and fair elections for the legislature; iii) consist of an independent judiciary; iv) maintain protection of personal liberties through constitutional or other legal guarantees. The ICRG measure of institutional corruption measures the actual or potential corruption present in the political system by gauging excessive patronage, nepotism, job reservations, 'favor-for-favors', secret party funding, and suspiciously close ties between politics and business. Political rights

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[2] The dependent variable in our study is average annual growth per capital GDP. Real GDP per capita is used to compute an annualized average growth rate according to $(1/2)\left[\ln(y_t) - \ln(y_{t-2})\right]$. Though it is standard practice in cross-country growth regressions to utilize 5 year lags, since our study comprises of 21 observations per group, using 5 year lags to compute the growth rate would lead to observation loss of 3 per group. Thus, we use 2 year lags for computing the growth rate in order to maximize the number of observations present for regression analyses.

[3] The ICRG dataset was kindly provided by Sambit Bhattacharyya, the Senior lecturer at the Research School of Pacific & Asian Studies, ANU.

[4] This study uses political risk measures from the ICRG database. The measurement of political risk, unlike economic risk, is based on subjective staff analysis based on available information. ICRG editors assign points to each category of political risk based on pre-set questions, which ensures subjective consistency over time. The ICRG system was adjusted in late 1997 to reflect the change in the institutional environment as a result of the ending of the Cold War. This structural adjustment did not retroactively change the political risk variables. This ensures the variables used in the construction of a quality index retain consistency.

measures the degree of freedom in the voting process and the degree of fair competition of a variety of interest groups.. The measurement of political rights is characterized by voting autonomy for minority groups, political competition, and political recourse for all citizens. All measures are between zero and seven where zero is representative of a low degree of accountability, corruption and political rights, and a measure of seven is indicative of a high degree of accountability, corruption and political rights. This composite measure of institutional quality is suitable to our study for the following reasons: i) it is best-suited to capture the notion of institutional quality z, expressed in the theoretical section of this paper; ii) since it is an ordinal measure, it enables the interpretation of different degrees of institutional quality; iii) Since it covers the time period of our study, 1984-2007, and utilizes the most number of observations relative to other measures of institutional quality. This enables us to take advantage of panel regression analysis and helps avoid the problem of sample selection bias both across groups and over time; iv) ICRG data are widely used in the literature on cross country growth regressions.

Bulir and Hamann (2003) note that due to insufficient data cross country studies do not employ sector-specific aid flows, but rather a composite/aggregated measure of aid. Those studies which have employed sector specific analysis of aid flows retain largely inconclusive results[5]. Therefore, our computation of aid volatility and aid per capita do not utilize sector-specific aid but rather, aggregated aid data gathered from the OECD database for net official development assistance.

Net official development assistance is a measure of a country's gross disbursements less its loan repayments. Real aid data was computed by deflating the aid series using an implicit GDP deflator (2005 = 100). A real per capita measure was computed by adjusting the real aid data series with an absolute measure of the size of population. The measure of total population was collected from WDI. Real aid per capita is a more useful measure than absolute real aid or real aid as a proportion to GDP because it takes into account the magnitude of aid a country is receiving relative to its size. The measure of absolute aid may overstate the magnitude of total aid for larger countries (i.e. with higher populations) and may understate them for smaller countries (with smaller populations). Thus, the magnitude of aid should be computed with respect to the size of the aid receiving country. Aid as a proportion to GDP may also prove problematic. Suppose there are two aid recipients, A and B, with identical GDP at time t. If we assume A grows faster than B, then A has a smaller GDP at $t-1$ relative to B. Given both recipients receive the same amount of aid, this implies that aid as a proportion to GDP is larger for A at $t-1$. For country A, we interpret a higher correlation between aid and GDP –i.e. higher aid is necessarily results in higher output. This is, however, spurious. The difference in growth rate of GDP is driving the result. Even if we assume that each country receives different amounts of aid, it is hard to separate the effect of aid on output because of the interaction of different growth rates influencing the denominator in $\mathrm{Aid/Gdp}$.

We apply the Hodrick-Prescott (HP) filter to de-trend a logged real aid per capita. The HP filter splits the aid series into a growth or trend component (g_t) and a cyclical or noise component (τ_t). We compute aid volatility by taking the standard deviation over

[5] A study by Clemens, Radelet and Bhavani (2004) is an exception.

3 year time periods of τ_t [6]. Averaged over the sample period, Kyrgyz Republic has the lowest aid volatility of 0.006 with an average value of 0.285 while Bahrain has the highest aid volatility of 2.954 with an average value of 0.931.

We use the aid volatility measure computed through the HP filter due to the following advantages: i) the filter has been used widely in macroeconomics, specifically business cycle analysis, and thus its methodological approach and properties are widely understood and accepted; ii) its filtering process is founded on the assumption that a macroeconomic series is composed of a trend and cyclical component; iii) it produces a difference between the actual and trend series that is stationary and it enables the trend component to follow a stochastic process (Yap 2003); iv) it has been widely used in aid-growth regressions (such as Bulir & Hamann 2003; Arellano et. al 2009; Hudson & Mosley 2008) which render the results of these studies comparable.

Inflation, financial development and balance of payments are often used macroeconomic policy variables in cross country regression studies. According to Fischer (1993) inflation is the best indicator of macroeconomic policy environment as it reflects the ability of the government to manage the economy. Low and stable levels of inflation, spur growth for given levels of investment (Durbarry et al., 1998), while higher and more volatile episodes of inflation lead to the dilution of relative price signals through price volatility (Clemens 2010). Inflation has been found to be significant and negatively related to growth in several studies. In this study we utilize Log (1+inflation) to capture the level of inflation in the economy. Financial development or financial liberalization is also incorporated as a standard control variable in conventional aid-regression studies. Higher financial development stimulates economic growth through the expansion and improvement in the efficacy of the nation's financial institutions, such as greater mobilization of savings and increased risk management services, which leads to greater investment expenditure (Clemens 2010). We incorporate this variable in our regressions by measuring M2/GDP, which studies use as a proxy for financial development.

For simplicity and exposition we construct a macroeconomic policy index combining inflation and financial development. We normalize both variables using the following transformation formula: $\frac{x-\overline{x}}{s}$, where x is the observation, $\overline{x}$ is the sample mean and s is the sample standard deviation. We weigh inflation and financial development according to each variable's correlation with growth. This is performed by OLS regression.

Additional control variables we utilize are investment and log of initial GDP per capita, along with various additional covariates.

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[6] The filter identifies the cyclical component of aid, $A_t - g_t^{aid}$ (via locating a g_t^{aid}) from the minimization trade-off by the extent to which the aid growth component keeps a track of the original aid series, given a prescribed value for the lack of smoothness of the growth component. (Ahumada & Garegnani 1999).
As λ approaches 0, the prescribed penalty is absent and the growth component is equivalent to the original aid series. In this case, the cyclical component is zero.
As λ approaches infinity, on the other hand, the growth component diverges from the original aid series and as a result the cyclical component approaches a linear trend.

Two issues that need to be dealt with in our estimation are potential correlation between aid volatility and institutional quality and omitted variable bias. We find that the correlation coefficient between z_{irt} and v_{irt} is -0.078. The magnitude of this correlation is not large enough to cause multi-collinearity issues. We handle the issue of omitted variable bias by controlling for unobserved region and specific heterogeneity, time-varying characteristics (e.g. shocks), additional controls, which are expected to impact the level of growth.

Our benchmark model is estimated using OLS, fixed effects (FE) and random effects (RE). OLS pools observations across cross sections and by using all the variation in the data tends to be more efficient than performing individual OLS on repeated cross sections. The drawback of the pooled OLS is that it does not account for potential endogeneity of the independent variables with respect to country-specific variations which are unmodelled and unobserved. In general, the variables measured with an error term tend to display a bias toward zero and OLS does not account for standard errors from the first stage estimator (see Arellano et al. 2009).

The RE estimator is advantageous over OLS in that it provides efficient estimates in the presence of country-specific factors which are correlated with the independent variables. The RE estimator controls for time-invariant differences as well as time-varying difference between the sample of countries such that the estimated coefficients for equation (15) will not be biased due to omitted time-invariant characteristics and time-varying characteristics. The FE estimator is a special case of the RE estimator and controls for time-invariant differences.

The FE and RE estimators, however, have their limitations: estimates may be biased or inconsistent if the independent variables are correlated with the error term. The FE estimator is inconsistent when the time dimension T , is small relative to country dimension N , and the RE estimator is inconsistent because the transformed regressions are correlated with the transformed errors (Ralhan & Dayanandan 2005). The proposed solution to this problem was forwarded by Arellano and Bond (AB, 1991), who pioneered the differenced-GMM estimator (DIFF-GMM) while Blundell and Bond (BB, 1998) conceptualized the system-GMM (SYS-GMM)[7]. These estimators help overcome the problem of endogeneity between the set of cross-country independent variables and other country specific characteristics. It is also appropriate to utilize the GMM estimators when: i) there are more moment conditions than model parameters; and ii) the panel dataset consists of a large country dimension relative to a smaller time dimension[8]. Identification in both types of estimators is based on first-differencing and using lagged values of the endogenous variables as instruments. In the difference-GMM estimator (GMM-DIFF), lagged levels are used to instruments for the differenced right hand side variables, while for the system-GMM estimator (GMM-SYS) the estimated system is composed of a difference equation instrumented with lagged levels and additionally a level equation, which is estimated using lagged differences as instruments (Bond et al. 2001; Rajan & Subramanian 2008). GMM-DIFF and GMM-SYS both have their limitations: the GMM-DIFF may lead to weak-instruments problem due to lagged levels not being correlated with their differenced counterparts; on the other hand, the GMM-SYS as the tendency to generate large upward biases in the estimation of

[8] If the time dimension is large, then dynamic panel bias becomes insignificant – in such a case, a fixed estimator is recommended (see Roodman 2006). Further, as the time dimension of the panel increases, the number of instruments in the GMM-SYS and GMM-DIFF tends to explode; additionally, as the cross-sectional dimension increases, the Arellano-Bond autocorrelation test may become unreliable.

the right hand side variables (Hauk & Wacziarg, 2004). Further, for the GMM-DIFF, the level equation instruments, i.e. the lagged differences of the endogenous right hand side variables, are valid only if they are orthogonal to the fixed effect. Additionally, estimates using difference-GMM tend to display a severe downward bias though the system-GMM is found to be more efficient and a more inherit valid instrument sets (Presbitero 2006). Due to neither estimator being perfect, we report for both GMM-DIFF and GMM-SYS. The instruments we use for difference-GMM are the potentially endogenous variables themselves. The system-GMM uses second order and deeper lags in differences and levels of the potentially endogenous regressors.

We employ the following specification tests to support out main hypothesis:

i) Instrument validity by using Hansen's J statistic of over-identifying restrictions[9].

ii) Arellano & Bond (1991) AR (1) & AR (2) tests for first and second order serial autocorrelation.

iii) Hausman test to gauge whether the more efficient model (i.e. the RE), against a less efficient but consistent model (i.e. the FE), also gives consistent results (Hansen & Tarp 2000; Clements et. al. 2003; Masud & Yontcheva 2005).

iv) F-test to check whether the coefficients in the FE and RE models are zero.

Our data set is composed of 77 aid recipients. The time period of the study is from 1984 to 2007. The starting year is restricted by the availability of the ICRG dataset and the end year is a function of the lack of availability of aid data for Armenia, Azerbaijan, Belarus, Estonia, Latvia, Lithuania, Moldova, Kazakhstan, Kyrgyzstan, Tajikistan, and Ukraine from 2007 onwards. Excluding these countries, which are of the same economic bloc, may bias the results. Thus, we have included them and as a consequence our series is limited to the year 2007.

5. Empirical Results & Discussion

The data appendix (at the end of the paper) gives an account of the main variables used in our model, their description and computation. Table 1 reports the descriptive statistics of the main variables of equation (15).

Table 2 shows the results of equation (15). Moving from column 1 to the right we add more right hand side controls and allow variables in equation $\sum_{j=1}^{k}\delta_j X'_{irt}$ to be endogenous. Column (1) illustrates the effects of institutional quality and aid volatility on growth using pooled OLS. The results show that aid volatility is negatively related to growth. The interaction term is positive and strongly significant. This illustrates that a one unit increase in quality (for a given level of aid volatility) mitigates the negative impact of volatility on growth. Thus, the interaction term is included to capture the belief that better quality institutions have a mitigating effect on the negative impact of aid volatility on a country's growth. Turning to the other variables estimated using

[9] The Hansen's J statistic is used in place of the Sargan test of over-identifying restrictions because of its consistency in the presence of autocorrelation and heteroscedasticity (Neanidis & Varvarigos, 2009; Roodman, 2007). We make sure we check whether deeper lags of the instrumented variables are correlated with deeper lags of the disturbances.

OLS: institutional quality retains an intuitive sign and strongly significant sign. Column 2 displays the results of the relationship between institutional quality, aid volatility and growth by adding more controls, such as investment, initial per capita GDP, aid per capita and policy. Our variables of interest continue to be strongly significant. Institutional quality remains significant, though at the 5 per cent level. Investment and initial per capita GDP retain intuitive signs yet initial per captia GDP is not found to be significant. The sign of our policy variable aligns with the literature: an increase in the policy (i.e. a decrease in inflation or a rise in financial development) leads to an increase in the economic growth. The estimate for aid per capita retains a negative and insignificant sign. There are a number of reasons why foreign aid may be negatively correlated with growth: i) aid receipts expand a government's resource base and subsequently reduce its efficiency in collecting taxes, fostering aid dependence and fiscal ill discipline, both of which are inimical to economic growth; ii) aid receipts may also have an adverse influence on the corruptibility of the incumbent government, since large aid inflows may decrease government accountability (Adam and O'Connell 1999, Levy 1988); iii) when part of the aid inflows is spent domestically on non-traded goods and services there is excessive demand of non-tradables over tradeables which subsequently increases the relative price of non-tradeables over tradeables, inflating the real domestic exchange rate, which harms longer run economic growth (termed the Dutch Disease). Column 3 and 4 shows the results of our FE and RE estimators while columns 5 and 6 display output from GMM-SYS and GMM-DIFF, respectively. In column 3, the coefficients of our variables of interest reduce in magnitude but still remain strongly significant at the 1 per cent level. Coefficients from other variables continue to possess appropriate signs; however, initial GDP per capita becomes significant while investment becomes insignificant. The hausman test indicates that the FE estimator is valid over the RE. In columns 5 and 6, the values of the coefficients of interest are increasing in magnitude and remain strongly significant. In Table 2, all types of estimators produce strongly significant signs consistent with case 1 from our theoretical section. Furthermore, our policy index, a composite measure of inflation and financial development, is likely to be correlated with other country specific cultural, socioeconomic characteristics such as fertility, distribution of income, social capital, etc. (Easterly & Levine, 1997; Alesina & Rodrik, 1994; Temple, 1998). Our aid variable may be correlated with income distribution: a rise in income may result in decreased aid flows (Turnbull & Wall, 1994; Alesina & Dollar, 2000). This implies that aid volatility and income volatility share a negative correlation. Indeed, Ramey & Ramey (1995)[10] have shown that income volatility has a strong negative correlation with developing country growth. Due to these endogenous relationships among variables, we treat the signs and significance of columns 1 through 4 with caution. For the GMM-SYS and GMM-DIFF estimations, however, the *p* values of the Hansen *J* statistic (0.890/0.272) along with the AR(1) and AR(2) values (0.000/0.289 and 0.000/0.531, respectively) indicate that the instruments (i.e. lags of order 2 and 3 of the endogenous regressors) are orthogonal to the error term and that the error term is not auto-correlated. Since this is the case for all the system GMM estimations below we will rely more on the GMM results than OLS, FE and RE estimations.

Using the column 5 as our baseline regressions results, we notice that in an average country, aid volatility affects growth negatively unless the institutional quality is above a threshold of 3.52 out of 7 (where 7 represents absolute incorruption). Differentiating our baseline equation () with respect to aid volatility we obtain, $\gamma_2 + \gamma_3 z_{irt}$. Since our mean for institutional

[10] See also Aizeman & Marion, 1999. "Volatility & Investment: Interpreting Evidence From Developing Countries".

quality is 2.52, the term $\gamma_3 z_{irt}$ on average does not outweigh γ_2 for all observations on quality, and thus, we intuitively expect $\frac{\partial growth}{\partial V}$ <0, which is confirmed by a host of aid volatility studies (see Bulir and Hamann 2008, Fielding and Mavrotas 2006, Lensink and Morrissey 2000, Arellano et al 2009).

Few studies exploring the impact of aid volatility on growth have scrutinized the broader applicability of their results through robustness testing. Easterly (2003) and Roodman (2004) demonstrate that most baseline empirical results are susceptible to changes in specification, definition of variables, etc.

To account for such potential sensitivity in our baseline results, we gauge their robustness by testing the following: i) additional covariates from the aid-growth literature; ii) different levels of smoothing parameters; iii) an alternative measure of aid volatility; iv) non-linearities; and v) alternate samples.

We test the strength of our key explanatory variables by incorporating additional covariates, such as life expectancy, fertility, geography, population, trade share, schooling, ethnic fractionalization, real openness, budget balance, and mortality, which have been found in the aid-growth literature to have a significant impact on developing country growth (Barro & Sala-i-Martin, 1995; Burnside & Dollar, 2000; Clemens et. al, 2004; Varvarigos & Neanidis, 2009; Arellano et. al, 2009; Lensink & Morrissey, 2006; Rajan & Subramaniam 2008). Though not a comprehensive set of additional covariates, for the purposes of this paper, they serve as a set of plausible (even if restricted) set of covariates which explain a substantial variation in the data, and hence allow us to check whether the estimates of the key explanatory variables are robust in a standard specification. The results are reported in Table 3. We note that controlling for additional covariates does not alter the baseline results. Both aid volatility and institutional quality are appropriately signed at the 1 per cent significance level. Coefficients of the additional control variables which are significant are life expectancy and education. Both have a positive sign, reflecting the positive impact that initial life expectancy and schooling have on growth. Other additional controls have their expected signs.

We also explore how changes in the smoothing parameter contained in the Hodrick-Prescott affect our key explanatory variables. Researchers follow Hodrick and Prescott (1980, 1997) when applying the filter to quarterly data. Most applications of the HP filter are concerned with de-trending quarterly data and few researchers are in agreement on the value of the smoothing parameter, λ, when the filter is applied to annual data. Maravall & del Rio (2007) recommends using a value of λ between 6 and 14, Backus and Kehoe (1992) use 100, while Baxter and King (1999) suggest a value of 10. Ravn and Uhlig (2002) follow analytical methods to determine the optimal smoothing parameter. The first approach shows that aggregating observations changes the ratio of the variance between the cyclical component and the second difference of the trend component by the fourth power of the frequency of observations. That is, the approach yields a value of $\frac{1600}{4^4} = 6.25$. The authors test the optimal smoothing value by de-trending a U.S GDP data series and using $\lambda = 6.25$ for annual data and $\lambda = 1600$ for quarterly data, and find both series' producing the same trend. Following Ravn and Uhlig (2002) we use $\lambda = 6.25$. In the robustness tests we employ lamda set to 10, 30, 75 and 100 and compare these to our baseline sample. Results are reported in Table 4. Our variables of interest statistically survive various computations of aid volatility and are significant at least at the 5 per cent level. This suggests that the results in our baseline sample are not biased by the choice of lambda.

Following Afonso & Fureri (2008) we test the sensitivity of our baseline results against an alternative measure of aid volatility. We utilize the Baxter King bandpass filter (BK filter) to compute an alternative measure. The BK filter removes both high and low frequency components of the series, leaving business-cycle frequencies. Baxter & King (1999) argue that the optimal filter is a moving average process with an infinite order. For practical purposes, however, we must approximate the filter with finite moving averages. In their paper, they recommend using a 7-year centered moving average when dealing with quarterly or annual data. Results using the BK filter as a measure for aid volatility are reported in Table 5. Using BK filter to compute aid volatility does not alter our baseline sample results: key variables are significant at least at the 5 per cent level.

Further, we test the strength of significance of our key variables by incorporating non-linear variables in our baseline equation. Hadjimichael et al. (1995) were one of the first authors to employ non-linear effects of aid. Non-linear aid effects may be present for the following reasons: i) Due to absorptive capacity constraints a country may possess limited capacity (beyond a specific threshold) absorbing aid inflows into productive works; ii) Aid given beyond a specific threshold may be harmful for the country's economic conditions. Several studies on aid-growth regressions have highlighted the importance of recognizing non-linearities (Durbarry et al., 1998; Lensink and White, 2001; Hansen and Tarp, 2000, 2001). Following Rajan & Subramaniam (2008) and Hansen & Tarp (200), we include the interaction between aid and policy, aid and geography and an aid squared and policy squared terms in our baseline regression. The variables of interest continue to be strongly significant at the 5 per cent level.

Table 7 presents robustness results with alternative samples. Columns 1 through 4 test the sensitivity of the baseline results with respect to particular continent. We subtract those countries in the African continent, Asian continent, European continent and those in the Americas one at a time from our base sample. Our results remain comfortably significant at least at the 5 per cent level in all cases save for column 2. The signs for the coefficients appearing in column 2 are only marginally significant (i.e. at the 10 per cent level). Eliminating European countries from our base sample may eliminate some highly corrupt countries experiencing extreme aid volatility, and thus, may eliminate substantial variation in our data. That is, eliminating European countries decreases sample heterogeneity because of selecting out an economic bloc containing countries with similar historical, economic and political factors shaping the quality of their institutional environments. In columns 5 through 7 we eliminate former British, Spanish and French colonies from our baseline sample. The signs and significance for our key variables remain unaffected at the 1 per cent level. The literature on aid-growth has documented potential problems caused by outliers (Burnside & Dollar 2000; Gomanee *et al* 2002; Hansen & Tarp 2000, Dalgaard & Hansen 2001). Following Hodler & Bhattacharyya 2010, in columns 8 and 9 we omit influential observations by using Cook's distance and DFITS. Cook's distance proposes that an observation is to be deemed an outlier and thus omitted if $|cooksd_i| > 4/n$ while DFITS test eliminates observations if $|DFITS_i| > 2(k/n)^{1/2}$, where k is the number of independent variables in the baseline equation and n is the number of observations in the baseline sample (see Belsley et al. 1980) Our key variables survive these tests.

Our baseline regressions use 3 year averages. Easterly (2003) and Roodman (2007), however, show how different period averages significantly alter baseline results. Since cross country growth regressions utilize 4/5 year averages and sometimes 9 year averages (see Varvarigos & Neanidis, 2009) in order to test the longer run effects of key variables on economic growth, we compute 7 year and 11 year period averages to test the significance of our key variables. To estimate these longer run averages we employ FE over GMM-SYS and GMM-DIFF due to the constraint of having lesser number of observations than the number required to take 2nd order lags in GMM-estimations. These results support our baseline findings – the volatility and interaction terms are significant at least at the 5 per cent level[11].

6. Conclusion:

We study the effects of an increase in aid volatility on growth as well as an increase in the institutional quality on the marginal impact of aid volatility on growth. Using a simple utility maximization framework, we analyze the tradeoff between government self-consumption (corruption) and longer term infrastructure investment. Comparative statics highlight how aid volatility has a negative effect on growth, while an increase in institutional quality mitigates the negative marginal impact of aid volatility under specific conditions with respect the government's and households' marginal utility.

The empirical findings accord with case 1 from our theoretical model. That is, we find that governments in our sample of countries face a situation of increasing marginal benefits in consumption equal to or greater than those of households. This implies that given an increase in institutional quality, governments are inclined at the margin to raise optimal public investment and transfers expenditure in the face of higher aid volatility due to fear of losing office. Our empirical results confirm this theoretical prediction over various computations of aid volatility, sub-samples, additional covariates and non-linearities.

With respect to policy prescriptions, foreign aid would be more effective if aid volatility were reduced and the quality of institutions strengthened. It would be more wise a practice for international agencies such as the International Monetary Fund (IMF) and The World Bank to take on board a prescriptive aid policy plan for LDCs by incorporating institutional quality into their calculus as a factor of considerable weight. The IMF and The World Bank have thus far provided analytical support for aid policy implementation with respect to corruption and aid volatility as factors having separate merit. A suggestion would be to take both factors into account simultaneously and in an integrated fashion when evaluating aid programs. It is required that the actual level of aid given to LDCs be more consistently aligned with the expected levels of aid, while at the same time, developing stronger democratic, accountable and less corrupt systems of governance. In this way, aid-recipient countries facing more predictable aid flow disbursements and enjoying higher levels of institutional quality are more likely to devote aid expenditure to productive investment rather than corrupt private expenditure.

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[11] Results are not reported to save space, but are available upon request.

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RESULTS & DATA APPENDIX

TABLE 1. – Summary Statistics.

Variable	Mean	St.dev.	Min	Max
Average annual growth Per Capita	0.009	0.058	-0.406	0.122
Institutional Quality (z)	2.521	1.069	0.000	5.000
Aid volatility (v)	0.286	0.404	0.006	2.954
Interaction $(z \times v)$	0.682	1.142	0.000	12.303
Investment	20.937	6.785	3.246	57.394
Initial Income	7.015	1.300	4.416	10.459
Aid per capita	5.933	9.193	0.000	67.929
Policy	0.004	5.885	-17.465	14.868
N= number of observations	469			

TABLE 2: Impact of Volatility & Interaction Effects on Growth, OLS, FE/RE and GMM Estimations (Dependent Variable is Average Annual Growth of Per Capita GDP)

	(1)	(2)	(3)	(4)	(5)	(6)

	OLS	OLS	FE	RE	GMM-SYS	GMM-DIFF
Quality	**0.008****	**0.007****	**0.016*****	**0.008***	0.005	0.010
	(0.002)	(0.030)	**(0.005)**	(0.093)	(0.486)	(0.340)
Volatility	**-0.096*****	**-0.107*****	**-0.900**	**-0.107*****	**-0.155*****	**-.171*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.001)**	**(0.004)**
Interaction	**0.028*****	**0.028*****	**0.026*****	**0.032*****	**0.044*****	**0.052*****
	(0.000)	**(0.002)**	**(0.002)**	**(0.000)**	**(0.002)**	**(0.004)**
Investment	-----	**0.001*****	0.001	**0.001*****	**0.002****	.002
		(0.000)	(0.239)	**(0.008)**	**(0.013)**	(0.188)
Initial GDP per capita (ln)	-----	-0.003	**-0.086**	-0.004	-0.004	-0.030
		(0.189)	**(0.000)**	(0.164)	(0.359)	(0.349)
Aid per capita	-----	-0.0002	0.0002	-0.0002	-0.0002	0.001
		(0.411)	(0.764)	(0.622)	(0.654)	(0.286)
Policy	-----	**1.650*****	**1.385*****	**1.637*****	**3.060*****	**2.655*****
		(0.000)	**(0.001)**	**(0.000)**	**(0.000)**	**(0.001)**
Countries/*N*	77/469	77/469	77/469	77/469	77/469	77/469
adj. R^2	0.250	0.32	0.021	0.33		
Endogenous variables used as instruments					Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment
No. of lags of endogenous variables used in instrumentation					Three	Three
AR(1) test (*p*-value)					0.000	0.000
AR(2) test (*p*-value)					0.289	0.531
Chi-square (Hansen *J*-statistic)					0.890	0.272
F-test			0.000	0.000		
Hausman test			chi2(7)= 104.22 (0.000)			

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

TABLE 3: Impact of Volatility & Interaction Effects on Growth with Additional Controls, GMM Estimations (Dependent Variable is Average Annual Growth of Per Capita GDP)

	(1) GMM	(2) GMM	(3) GMM	(4) GMM	(5) GMM	(6) GMM	(7) GMM	(8) GMM	(9) GMM	(10) GMM
Quality	0.003 (0.697)	0.007 (0.428)	0.005 (0.472)	0.005 (0.487)	0.006 (0.411)	**0.014*** **(0.060)**	0.005 (0.471)	0.003 (0.673)	0.006 (0.431)	**0.013***** **(0.192)**
Volatility	**-0.162***** **(0.000)**	**-0.152***** **(0.001)**	**-0.155***** **(0.001)**	**-0.156***** **(0.001)**	**-0.159***** **(0.001)**	**-0.116***** **(0.000)**	**-0.154***** **(0.002)**	**-0.203***** **(0.000)**	**-0.155***** **(0.004)**	**-0.145***** **(0.000)**
Interaction	**0.049***** **(0.001)**	**0.042***** **(0.005)**	**0.044***** **(0.003)**	**0.045***** **(0.003)**	**0.045***** **(0.002)**	**0.031***** **(0.009)**	**0.044***** **(0.004)**	**0.054***** **(0.000)**	**0.044***** **(0.008)**	**0.030***** **(0.000)**
Investment	**0.002**** **(0.065)**	**0.002***** **(0.007)**	**0.002**** **(0.042)**	**0.002**** **(0.033)**	**0.002**** **(0.027)**	**0.003***** **(0.000)**	**0.002**** **(0.016)**	**0.002** **(0.111)**	**0.002**** **(0.056)**	**0.002**** **(0.022)**
Initial GDP per capita (ln)	**-0.007*** **(0.239)**	-0.002 (0.576))	-0.004 (0.393)	-0.004 (0.389)	**-0.006** **(0.160)**	**-0.013***** **(0.002)**	-0.004 (0.382)	**-0.004** **(0.437)**	-0.003 (0.453)	**-0.006*** **(0.062)**
Aid per capita	**0.001** **(0.440)**	0.001 (0. 250)	-0.0002 (0.613)	**-0.003** **(0.601)**	**-0.0002** **(0.770)**	**-0.0002** **(0.704)**	**-0.0001** **(0.826)**	**0.0002** **(0.815)**	-0.0002 (0.544)	**-0.0004***** **(0.638)**
Policy	**2.94***** **(0.000)**	**2.771***** **(0.000)**	**3.131***** **(0.000)**	**3.096** **(0.000)**	**2.914** **(0.000)**	**1.970***** **(0.009)**	**3.070** **(0.000)**	**2.785** **(0.000)**	**3.121***** **(0.000)**	**2.281** **(0.002)**
Life exp(ln)	0.006 (0.596)									
Fertility		**-0.005**** **(0.048)**								
Geography			-0.0001 (0.878)							
Population				-0.000 (0.867)						
Trade Share					0.018 (0.111)					
Schooling						**.0004*** **(0.065)**				
Ethnic Frac							-0.005 (0.795)			
Real Openness								0.0002 (0.277)		
Budget Balance									0.0003 (0.248)	
Mortality										-.0009 (0.605)
Countries/*N*	77/453	77/469	77/469	77/469	77/469	77/469	77/469	77/469	77/469	77/469

Endogenous variables used as instruments	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment
No. of lags of endogenous	Three	Three	Three	Three	Three	Three	Three	Three	Three	Three
AR(1) test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) test (*p*-value)	0.219	0.275	0.294	0.292	0.303	0.160	0.288	0.170	0.409	0.121
Hansen *J*-statistic	0.812	0.791	0.803	0.807	0.771	0.662	0.776	0.840	0.863	0.788

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

TABLE 4: Impact of Volatility & Interaction Effects on Growth with Different Smoothing Parameters (Dependent Variable is Average Annual Growth of Per Capita GDP)

	(1) GMM-DIFF	(2) GMM-SYS	(3) GMM-DIFF	(4) GMM-SYS	(5) GMM-DIFF	(6) GMM-SYS	(7) GMM-DIFF	(8) GMM-SYS
Quality	0.008 (0.453)	.002 (0.836)	0.008 (0.438)	.003 (0.566)	0.008 (0.423)	0.004 (0.452)	0.008 (0.396)	0.005 (0.385)
Volatility ($\lambda = 10$)	-0.164*** (0.009)	-0.159 (0.002)	-----	-----	-----	-----	-----	-----
Volatility ($\lambda = 30$)	-----	-----	-0.157 (0.011)	-0.147*** (0.002)	-----	-----	-----	-----
Volatility ($\lambda = 75$)	-----	-----	-----	-----	-0.147 (0.008)	-0.135 (0.000)	-----	-----
Volatility ($\lambda = 100$)	-----	-----	-----	-----	-----	-----	-0.142 (0.006)	-0.128 (0.001)
Interaction ($\lambda = 10$)	0.050*** (0.002)	0.047*** (0.002)	-----	-----	-----	-----	-----	-----
Interaction ($\lambda = 30$)	-----	-----	0.048*** (0.003)	0.042*** (0.002)	-----	-----	-----	-----
Interaction ($\lambda = 75$)	-----	-----	-----	-----	0.045 (0.002)	0.039 (0.001)	-----	-----
Interaction ($\lambda = 100$)	-----	-----	-----	-----	-----	-----	0.044 (0.002)	0.038 (0.001)
Investment	0.002 (0.229)	0.001 (0.139)	0.002 (0.212)	0.001 (0.111)	0.002 (0.165)	0.002 (0.109)	0.001 (0.126)	.002 (0.046)

Initial GDP per capita (ln)	-0.026 (0.467)	-0.005 (0.440)	-0.026 (0.480)	-0.001 (0.646)	-0.023 (0.523)	-0.003 (0.444(=)	-0.021 (0.555)	-0.004 (0.355)
Aid per capita	.0007 (0.551)	-.0006 (0.431)	.0006 (0.517)	-0.0003 (0.585)	.0007 (0.474)	-.0002 (0.674)	0.001 (0.421)	-.0001 (0.735)
Policy	2.615 (0.003)	2.615 (0.000)	2.565 (0.003)	2.702 (0.000)	2.495 (0.002)	2.851 (0.000)	2.484 (0.002)	2.927 (0.000)
Countries/*N*	77/396	77/469	77/396	77/469	77/396	77/469	77/396	77/469
Endogenous variables used as instruments	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment
No. of lags of endogenous variables used in instrumentation	Three	Three	Three	Three	Three	Three	Three	Three
AR(1) test (*p*-value)	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
AR(2) test (*p*-value)	0.755	0.535	0.735	0.506	0.711	0.471	0.697	0.474
Hansen *J*-statistic	0.295	0.860	0.279	0.882	0.267	0.822	0.252	0.790

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

TABLE 5: Impact of Volatility & Interaction Effects on Growth with alternative measure of aid volatility (Dependent Variable is Average Annual Growth of Per Capita GDP)

	(1) GMM-DIFF	(2) GMM-SYS
Quality	0.007 (0.609)	0.003 (0.740)
Volatility (using BK filter)	-0.210 (0.029)	-.191 (0.045)
Interaction	0.077 (0.026)	0.074 (0.028)
Investment	0.002 (0.270)	0.002 (0.385)
Initial GDP per capita (ln)	-0.082 (0.139)	-0.004 (0.448)
Aid per capita	0.002 (0.211)	0.001 (0.905)
Policy	4.262 (0.001)	3.356 (0.000)
Countries/*N*	77/396	77/469

Endogenous variables used as instruments	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment
No. of lags of endogenous variables used in instrumentation	Three	Three
AR(1) test (*p*-value)	0.003	0.001
AR(2) test (*p*-value)	0.800	0.872
Hansen *J*-statistic	0.447	0.603

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

TABLE 6: Effect of Non-linearities on the Impact of Volatility & Interaction Effects on Growth

	(1) GMM-SYS	(2) GMM-SYS	(3) GMM-SYS	(4) GMM-SYS
Quality	0.004	0.005	0.005	.005
	(0.583)	(0.431)	(0.438)	(0.487)
Volatility	-0.160	-0.149	-0.160	-0.155
	(0.000)	(0.002)	(0.001)	(0.001)
Interaction	0.045	0.043	0.043	0.045
	(0.002)	(0.003)	(0.004)	(0.003)
Investment	0.002	.001	0.002	0.001
	(0.019)	(0.009)	(0.028)	(0.013)
Initial GDP per capita (ln)	-0.003	-0.005	-0.004	-.004
	(0.451)	(0.275)	(0.402)	(0.328)
Aid per capita	-0.001	-0.0003	-0.002	-.0002
	(0.031)	(0.531)	(0.009)	(0.681)
Policy	3.017	3.578	3.162	3.137
	(0.000)	(0.000)	(0.000)	(0.000)
Aid x Geography	0.012			
	(0.050)			
Aid x Policy		-0.076		
		(0.383)		
Aid Squared			0.007	
			(0.017)	

Policy Squared				-74.779 (0.560)
Countries/*N*	77/469	77/469	77/469	77/469
Endogenous variables used as instruments	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment
No. of lags of endogenous variables used in instrumentation	Three	Three	Three	Three
AR(1) test (*p*-value)	0.000	0.001	0.000	0.000
AR(2) test (*p*-value)	0.284	0.299	0.263	0.317
Hansen *J*-statistic	0.825	0.818	0.829	0.799

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

TABLE 7: Impact of Volatility & Interaction Effects on Growth using alternate samples (Dependent Variable is Average Annual Growth of Per Capita GDP)

	(1) Base sample without Africa	(2) Base sample without Europe	(3) Base sample without Asia	(4) Base sample without Americas	(5) Base sample without British Colonies	(6) Base sample without French Colonies	(7) Base sample without Spanish Colonies	(8) Obs. omitted using Cook's Distance	(9) Obs. omitted using DFITS
Quality	0.012 (0.160)	0.010 (0.479)	0.006 (0.465)	0.008 (0.29)	0.007 (0.392)	0.004 (0.595)	0.010 (0.297)	0.002 (0.699)	0.002 (0.768)
Volatility	-0.136 (0.007)	-0.130 (0.073)	-0.157 (0.004)	-0.134 (0.006)	-0.167 (0.001)	-0.159 (0.002)	-0.145 (0.005)	-0.133 (0.001)	-0.134 (0.000)
Interaction	0.040 (0.016)	0.042 (0.084)	0.039 (0.014)	0.041 (0.023)	0.058 (0.001)	-0.158 (0.005)	0.048 (0.008)	0.032 (0.003)	0.034 (0.000)
Investment	0.002 (0.125)	0.001 (0.114)	0.002 (0.234)	0.002 (0.026)	0.002 (0.149)	0.002 (0.035)	0.002 (0.008)	0.002 (0.010)	0.002 (0.003)
Initial GDP per capita (ln)	-0.005 (0.291)	-0.005 (0.360)	-0.004 (0.434)	-0.007 (0.160)	-0.005 (0.215)	-0.004 (0.387)	-0.008 (0.106)	-0.002 (0.648)	-0.003 (0.353)
Aid per capita	-0.001 (0.394)	-0.001 (0.166)	-0.0001 (0.839)	0.0002 (0.732)	-0.0002 (0.619)	-0.0003 (0.522)	0.0001 (0.728)	-0.001 (0.181)	-0.001 (0.053)
Policy	3.074 (0.000)	2.183 (0.001)	3.165 (0.007)	4.113 (0.000)	3.653 (0.000)	3.048 (0.000)	3.996 (0.000)	1.430 (0.005)	1.724 (0.004)
Countries/*N*	56/332	65/397	57/336	64/375	68/408	75/455	64/382	77/434	77/439
Endogenous variables used as instruments	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment	Institutional quality, Interaction, policy, aid, initial GDP, investment

No. of lags of endogenous variables used in instrumentation	Two	Two	Two	Two	Two	Two	Two	Two	Three
AR(1) test (p-value)	0.000	0.000	0.000	0.000	0.000	0. 000	0.000	0.000	0.000
AR(2) test (p-value)	0.353	0.147	0.831	0.577	0.693	0.303	0.705	0.621	0.465
Hansen J-statistic	0.824	0.538	0.780	0.431	0.490	0.855	0.309	0.371	0.808

***, **, and * indicate significance level at 1%, 5% and 10% respectively, against a two-sided alternative. Figures in parentheses are p-values. All regressions except those in column (1) and (2) are carried out without an intercept. Constant terms, country and time dummies not reported.

Variable	**Definition**	**Source**
Democratic accountability	Ordinal data measured on a scale between 1 and 7. low accountability is represented by a number at the lower end of the scale; conversely, high accountability is indicated by a number at the higher end of the scale.	International Country Risk Guide (ICRG)[12]
Political Rights	Ordinal data measured on a scale between 1 and 7; Higher numbers on the scale represent weaker political rights	Freedom House
Institutional Quality	Equal weighted average of Democratic accountability and Political rights	
GDP per capita growth rate	Annualized average growth rate of GDP per capita	World Bank, WDI
Initial GDP per capita (log)	GDP per capita in constant 2000 USD for the first year of each period	World Bank, WDI
Investment	Gross Fixed Capital Formation (%) in constant 2000	World Bank, WDI
Volatility	Volatility of foreign aid for each period	Authors' calculations

[12] I'm grateful to Sambit Bhattacharyya for institutional quality data from the ICRG databases.

Variable Description

Volatility ($\lambda = 7$)	Volatility of foreign aid for each period obtained for a smoothing parameter of 7	Authors' calculations
Volatility ($\lambda = 30$)	Volatility of foreign aid for each period obtained for a smoothing parameter of 30	Authors' calculations
Volatility ($\lambda = 75$)	Volatility of foreign aid for each period obtained for a smoothing parameter of 75	Authors' calculations
Volatility ($\lambda = 100$)	Volatility of foreign aid for each period obtained for a smoothing parameter of 100	Authors' calculations
Policy Index	Composite index of M2/GDP and log inflation, where M2/GDP is defined as Money and quasi money (% of GDP in current USD) and log inflation is defined as Natural logarithm of 1+consumer price inflation	Authors calculations
Aid per capita	Official Development Assistance	OECD, DAC (online)
Life expectancy (log)	Life expectancy at birth, total (years)	World Bank, WDI
Interaction	Product of volatility and Institutional Quality each period	Authors' calculations
Fertility	Fertility rate, total (births per woman)	World Bank, WDI
Geography	Area in tropics (km squared)	World Bank, Global Development Network
Population	Total	World Bank, WDI
Trade share	Ratio of international trade to GDP in constant 2000 USD	Penn World Tables
Schooling	School enrollment, secondary (% gross)	World Bank, WDI
Ethnic Fractionalization	Degree of ethnic, linguistic and religious heterogeneity	Alesina et.al (2003)
Real openness	Nominal trade divided by PPP GDP	*Alcalá* and *Ciccone* (2001)/using Penn World Tables
Budget Balance	The ratio of general government budget balance to GDP	WDI
Mortality	Log of estimated mortality for European settlers during the early period of European colonization (before 1850);	Acemoglu et al. (2001), based on Curtin (1989) and other sources