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ON THE EMPIRICS OF FOREIGN AID AND GROWTH*

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The present paper re-examines the effectiveness of foreign aid theoretically and empirically. Using a standard OLG model we show that aid inflows will in general affect long-run productivity. The size and direction of the impact may depend on policies, 'deep' structural characteristics and the size of the inflow. The empirical analysis investigates these possibilities. Overall we find that aid has been effective in spurring growth, but the magnitude of the effect depends on climate-related circumstances. Finally, we argue that the Collier-Dollar allocation rule should be seriously reconsidered by donor agencies if aid effectiveness is related to climate.

The usefulness of foreign aid in promoting growth in developing countries has been an area of controversy ever since Rosenstein-Rodan in 1943 advocated for aid to Eastern and South-Eastern Europe. Browsing through successive editions of a leading textbook in development economics provides a telling illustration of how the confidence in aid effectiveness dwindled over the years. In the first edition of '*Leading Issues in Economic Development*', Meier (1964) dedicated a full 18-page section to the issue of foreign aid. He started out asking: 'How much aid?'. By the time of the sixth edition (Meier, 1995), the treatment of foreign aid had been cut into half, and the questions in focus were 'Why official assistance?' and 'Does aid work?'. In the 2000 edition (Meier and Rauch, 2000), 'foreign aid' is not even listed in the index.

However, in the last few years the pendulum has swung, and a gradually forming consensus view has emerged that aid 'works'. Indeed, panel-based empirical studies have repeatedly concluded that foreign aid does impact positively on growth. Nevertheless, controversy remains since it also seems clear from the data that foreign aid is far from equally effective everywhere. A key question is therefore what causes such differences in 'the return to aid'?

From a policy perspective, this issue is important as it ultimately influences the allocation of foreign aid across countries. Inspired by the work of Burnside and Dollar (2000) and Collier and Dollar (2001, 2002), which suggests that aid only works in places with 'good' policies, some donors are increasingly allocating aid to countries that perform well in terms of particular proxies for the policy environment. The motivation is clearly the desire to maximise the effectiveness of tax financed foreign assistance. However, if the variation in the effectiveness of aid on productivity is *not* policy induced but rather a result of other poor initial conditions a very different allocation rule would maximise the effect of aid donations on long-run productivity and poverty.

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In this paper we begin by fleshing out theoretical foundations for the various claims made with regard to the effectiveness of aid in stimulating long-run productivity. Foreign aid is modelled as an exogenous transfer of income or capital and the underlying economic framework is the overlapping generations model due to Diamond (1965). We parameterise the influence of the government and proceed to examine the conditions under which foreign aid enhances long-run productivity. In general, the impact of aid on steady state productivity is ambiguous. In particular, sufficiently poor economic management, on the part of the government, may render foreign aid ineffective. At the same time, however, deep determinants of productivity (factors that shift the production function) turn out to matter as well. Hence, 'strong' fundamental structural characteristics (like institutions and/or climate-related circumstances) may compensate for a bad policy environment. If, in the end, aid does have a positive effect on long-run productivity, diminishing returns may prevail. As such, it becomes evident that the driving force behind the variation in the degree of aid effectiveness is for empirical work to resolve.

Against this background we therefore proceed to the empirical evidence on the aid-growth nexus. After a brief review of key findings in the literature we go on to examine the importance of underlying structural characteristics for the return to aid. To avoid further problems with endogeneity, we use a measure of climatic circumstances (fraction of land in tropical areas) as a proxy for 'deep' structural charactaristics. This new specification, involving the interaction between aid and a climate-related variable, outperforms two of the more popular aid-growth relations in recent studies; the Burnside and Dollar (2000) policy interaction model and the diminishing returns model advocated by Dalgaard and Hansen (2001), Hansen and Tarp (2000, 2001) and Lensink and White (2001). The finding that aid seems to be less effective in the geographic tropics is robust to changes in estimation techniques and the underlying data.

There are a number of possible interpretations of this finding. The most obvious is that climate may matter directly for productivity, as it conceivably matters for how effective individual countries are in combining capital and labour to produce output; especially since many of the countries in the sample are reliant on agricultural production (Bloom and Sachs, 1998; Gallup *et al.*, 1999; Sachs, 2001, 2003; Masters and McMillan, 2001). Second, climatic circumstances may, for various reasons, have influenced the evolution of other slow-moving structural characteristics, like institutions (Hall and Jones, 1999; Acemoglu *et al.*, 2001, Easterly and Levine, 2003). As a result, the new interaction term may reflect that (exogenous) variation in institutions matter for the impact of aid on productivity. But regardless of the precise *modus operandi* the finding suggests, consistent with the theoretical model, that aid has been more effective in places with stronger slow-moving (or even time-invariant) structural characteristics.

In light of these findings we go on to discuss the implications for the aid allocation rule proposed by Collier and Dollar (2001, 2002). Collier and Dollar suggest an allocation rule based on an 'inverted' growth regression, in which the impact of aid varies with policy performance measured by the World Bank's CPIA index. The resulting rule states that aid should be directed towards poor countries with good policies (high CPIA scores).

We find a strong negative correlation between climatic conditions and CPIA ratings. Moreover, we document that the CPIA index is likely to be Granger caused by past growth performance. These findings lead us to question, not only the interpretation, but also the wisdom in using this allocation rule.

To summarise, the structure of the paper is as follows. Section 1 examines the effectiveness of aid theoretically, after which Section 2 is devoted to the empirics of foreign aid and growth. We summarise the debate but we also present new results and provide a rigorous analysis of issues related to the identification of the impact of aid on productivity. After discussing the implications of aid-effectivness for aid allocations in Section 3, a final Section of the paper is devoted to concluding remarks.

1. Aid Transfers and Growth Theory

Consider a two-period Diamond (1965) model augmented by an influx of aid. Accordingly, all markets are competitive, the economy is closed (except for the transfer), the population is growing at the rate $n > 0$ and, for simplicity, there is no technological progress. For brevity capital depreciation is also ignored. Perfect competition in factor markets imply that for any standard neoclassical production function exhibiting constant returns to labour and capital, GDP per worker, y_t, the real rate of interest, r_t, and the real wage in efficiency units, w_t, are uniquely determined – at any given point in time – by the capital/labour ratio, k_t. Hence $y_t = y(k_t)$, $r_t = r(k_t)$ and $w_t = w(k_t)$, respectively. Each period a fixed (in per capita terms) transfer of resources, x, enters the budget of consumers. Since the overlapping generations (OLG) framework inherently contains heterogenous agents it is necessary to specify how these transfers are divided between young and old citizens.

At time t there are L_t^y young agents, and L_t^o old agents ($L_t^y = (1 + n)L_t^o$). Hence, if the transfer is distributed equally across all the agents simultaneously alive, each group should be allocated a fraction of x equal to their respective population share. This would imply that the young obtain the share $\pi^y = (1 + n)/(2 + n)$ whereas the remainder, $\pi^o = 1/(2 + n)$, is allocated to the old citizens. In practice, however, foreign aid inflows are typically managed by the government. As a result, it is not obvious that the aid inflow will be distributed in this 'neutral' fashion. So in order to examine the implications of varying distributive rules, or the diversion of the transfer by the government, we assume the representative young household receives a transfer of the amount $\pi^y x$ while the representative old gets $\pi^o x$. If 'expropriation' is present this implies that $\pi^y + \pi^o < 1$. Since 'sound' economic management manifests itself in the way foreign aid is distributed, we may think of both the allocation of the transfer (i.e. the ratio π^o/π^y) as well as the levels of π^o and π^y as reflecting the 'policy environment' in aid receiving nations. Specifically 'bad policies' are associated with low levels of π^o and π^y as well as a disproportional allocation of resources to the non-investing citizens (here: the old). In practice this allocation decision is likely to be endogenous, and could reflect the power-struggle between competing interest groups and/or the incentives of the government to expropriate funds.[1] A number of papers in the literature have examined such channels, among them Boone (1996), Tornell and Lane (1999) and Svensson (2000). For present purposes, however, we will maintain the assumption that (π^o, π^y) are parameters. This will allow us to see clearly how government policies are mapped into the investment decision of the citizens, and ultimately influences 'the return to foreign aid'.

Naturally, 'policies' could be parameterised in various ways. For example one could add taxes to the model. As will be apparent in a moment this would not change any of the basic insights gained by parameterising policy by (π^o, π^y). In particular, the impact of changing the tax rate on capital income will be indistinguishable from an appropriate change in the π^o/π^y ratio.

Aside from these issues the structure of the model is the familiar one. People live only for two periods. In the first period of life they supply one unit of labour inelastically, they receive a transfer of resources, consume and save. In the second period of life, they consume the return on first period savings and a contemporary transfer. Assuming utility from consumption in youth and during old-age is logarithmic and that consumers discount the future at the rate ρ, it is straight forward to solve the problem of a representative young household. Since the capital stock in period $t+1$ derives solely from the savings of the young agents, it can subsequently be shown that the law of motion for capital per worker is:

$$k_{t+1} \equiv s(k_t, k_{t+1}; z)/(1+n) \tag{1}$$

where $z = \{x, \rho, n, \pi^y, \pi^o\}$, and

$$s(k_t, k_{t+1}; z) \equiv \sigma\left\{ w(k_t) + \left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(k_{t+1})}\right]\pi^y x\right\}. \tag{2}$$

The savings rate of the young, $\sigma \equiv 1/(2+\rho)$, is independent of the real rate of interest due to the assumption of log-utility. Appendix A discusses the formal properties of this model. In general it allows for both uniqueness and multiplicity of steady states. In what follows we focus on the case where the economy approaches a unique steady state capital-labour ratio, given implicitly by

$$k^* = s(k^*, k^*; z)/(1+n). \tag{3}$$

It now follows immediately that:

PROPOSITION 1 (Transfers in the Diamond model) *A permanent increase in the level of foreign aid per capita affects steady state productivity. Whether the transfer increases or decreases steady state production per worker depends on: (i) Policies (π^y, π^o), (ii) The production technology.*

[1] It is very plausible that such channels could be quantitatively important for the effectiveness of aid. For example, Reinikka and Svensson (2003) find that massive amounts of funds, intended for primary schooling in Uganda during the period 1991–5, seemingly disappeared. The authors also document that the extent of 'leakage' seems to vary across countries. At the same time, however, it is worth noting that some funds do find their way through the system. In terms of the model: $\pi^o + \pi^y$ may be 'small' but this term is not zero.

Accordingly, under very mild assumptions a foreign aid transfer will have a long-run impact on productivity. This result is in striking contrast to the result established in Obstfeldt (1999) where a symmetrical analysis is conducted but within a Ramsey-Cass-Koopmans (RCK) model. In the RCK model a very strong result holds:

PROPOSITION 2 (Transfers in the RCK model) *A permanent increase in the level of foreign aid (which enters the budget of the consumers) will raise the long-run level of per capita consumption one for one, but it leaves the steady state level of capital per worker unaffected.*

In other words, aid is ineffective even when the influence of the government is ignored. This result is invariant to assumptions made regarding production technology, i.e. whether growth is exogenous or endogenous (Obstfeldt, 1999). Thus, unless the model is somehow modified, aid is bound to be ineffective if the goal is to raise long-run productivity.[2] However, as the present analysis makes clear; this 'aid ineffectiveness result' is not due to the assumption of optimising households. Instead it follows from the assumption that households act as if they live for ever ('perfect' altruism).[3]

We now return to the present framework. Although aid clearly 'matters' it does not follow that it will be productive. Indeed, near the steady state there is a simple condition under which foreign aid will spur long run productivity:[4]

$$\frac{\partial k^*}{\partial x} \gtreqless 0 \text{ if } \frac{1+r(k^*)}{1+\rho} \gtreqless \frac{\pi^o}{\pi^y}, \qquad \pi^o, \pi^y > 0. \tag{4}$$

Clearly, $\partial k^*/\partial x > 0$ if the return to capital investments, r^*, is sufficiently high. Hence factors which shift the production technology upwards, and as a result increases the return to investments for any k_t, will tend to make it more likely that aid stimulates long run productivity. At the same time, however, sufficiently 'bad' policies (i.e. a counterproductive allocation of resources across agents) may render aid ineffective in raising long-run production. The intuition for the above condition is simple. Assume for the moment that $\pi^o/\pi^y = 1$. Under this assumption, aid will increase savings in so far as $r^* > \rho$. Increasing the level of aid, means that income in both periods of life is increased. If the optimal consumption-age profile is upward sloping, which corresponds to $r^* > \rho$, the consumer will respond to this 'windfall gain' by increasing savings so as maintain the desired profile. On the other hand, if $r^* < \rho$ the opposite occurs. Consequently, it is not surprising that insofar as the aid transfer grows over the life cycle ($\pi^o/\pi^y > 1$) then it becomes more likely that the consumer will cut

[2] The political-economy analysis by Boone (1996) is cast within a RCK model. For this reason aid *only* works in the model if it entices the government to lower distorting taxes on capital accumulation.

[3] Suppose the present OLG model is modified so as to allow households to obtain utility from the utility of their descendants and to pass on bequest. Then, if utility within and across generations are discounted at the same rate the 'RCK solution' obtains (Blanchard and Fischer, 1989, ch. 3). As a result, in this sort of an OLG model, aid would be unable to affect long-run productivity.

[4] See Appendix A.

savings, in response to an upward shift in the level of aid, so as to smooth consumption.[5]

Finally, as a prelude to the empirical discussion in what follows, we may use the model to clarify the alternative views that have been put forward in the recent aid-effectiveness debate.

First, the notion that policies are crucial in determining whether (and to which extent) foreign aid raises long-run productivity is reflected in the empirical strategy of Burnside and Dollar (2000) and Collier and Dollar (2001, 2002). They find that aid *only* works in places featuring a sufficiently sound policy environment. As we have just seen; policies matter in themselves, *and* sufficiently 'poor' policies may render aid ineffective in spurring growth.

Second, as is also clear from (3), the relationship between aid and long-run productivity is rather complicated. While policy and aid both have a direct impact on long-run productivity they matter in highly nonlinear fashions, and are mutually intertwined. Accordingly, in a reduced form sense we may think of long run productivity, y^*, as being a function, $\Theta(\cdot)$, of foreign aid, x, policies, π, and various other factors, δ, to which we shall return:

$$y^* = \Theta(x, \pi, \delta). \quad (5)$$

For the purposes of estimation this expression could be linearised. A second-order Taylor approximation of $\Theta(\cdot)$ would then yield various quadratic terms in π and x, along interaction terms involving x and π. The empirical work of Hansen and Tarp (2000, 2001) and Dalgaard and Hansen (2001) is founded in this view. The essential finding is that the marginal impact of aid, on productivity, seems to diminish as the size of the inflow rises. However, the interaction between policies and aid turns out to be insignificant.

Hence, to a significant extent the recent debate in the literature has been about second-order derivatives; the question of the relative importance of $\partial^2 y^*/\partial x\, \partial\pi$ vs. $\partial^2 y^*/\partial x^2$. Where Burnside and Dollar find that $\partial^2 y^*/\partial x\, \partial\pi > 0$, others have argued that $\partial^2 y^*/\partial x^2 < 0$, while $\partial^2 y^*/\partial x\, \partial\pi$ is insignificant. From a theoretical perspective little can be said about the relative merits of these different claims; both are *a priori* reasonable. As a result, it is an issue that has to be resolved empirically.

A third hypothesis that flows from the model is that fundamental (non-political) structural charactaristics matter for the return to foreign aid. In theory these are factors, which generate level differences in productivity and as a result matter for the return to investments. In terms of (5) these factors are encompassed in 'δ'. Likely candidates are the institutional framework of individual economies and/or various climate-related circumstances.[6] The observation that climate/geographic

[5] It is interesting to note how (4) relates to a RCK model. Suppose we have an equal amount of old and young agents present (say by setting $n = 0$). Consequently, let $\pi^o = \pi^y$. Now, in a RCK model the real rate of return is pinned down by the rate of time preference, ρ. Hence if we assume that $r^* = \rho$ and $\pi^o = \pi^y$ (4) is fulfilled with equality – the impact of aid on productivity is exactly zero; the RCK result.

[6] To our knowledge, the only study examining this sort of an interaction is Guillaumont and Chauvet (2001) who argue that aid effectiveness depends on the 'external environment'. Guillaumont and Chauvet create an index of external vulnerability based on stability measures of the agricultrual production, international trade, and the size of the population and find that higher vulnerability increases the returns to aid. Guillaumont and Chauvet also consider climate related differences but they embed these differences in the volatility of agricultural value added.

variables are strongly related to the growth performance of individual countries is not a novel notion. For example, Ram (1997) adds a variable measuring the distance to equator to an otherwise standard Mankiw *et al.* (1992) regression, and finds it to be highly significant. Likewise, the work surveyed in Sachs (2001) suggests that differences in climate appears to make a difference in terms of how effectively capital and labour combine to produce output. Controversy remains as to whether climatic variables affect economic outcomes directly, or only matter for productivity indirectly – through institutions say. This latter hypothesis is examined in Hall and Jones (1999), who find 'distance to the equator' to be a viable instrument for present day institutional quality. In a similar vein, Acemoglu *et al.* (2001) provide an intriguing discussion of how mortality patterns for European settlers in the late 19th century may have influenced current institutions and, ultimately, output per capita, within ex-colonies. Whatever the final outcome of this debate will turn out to be, the model suggests that aid, aside from potentially featuring diminishing returns and being intertwined with policies, may also be dependent on such 'deep' determinants of productivity. The next Sections confront these theoretical possibilities with data.

2. Aid Transfers and Growth Regressions

It should be clear by now that much of the current discussion centres on the question if bad policies – in addition to being detrimental to growth – imply that aid is wasted. As we have indicated above this is a question of second-order derivatives in growth models for which there is little theoretical guidance. As a consequence, Barro-style growth regressions on panel data have been used extensively in the controversy about the importance of good policy in aid receiving countries.

The origin of the debate was the analysis by Burnside and Dollar, first circulated as a World Bank working paper in 1996–7, later published in the *American Economic Review* (Burnside and Dollar, 1997, 2000). The results of this analysis also provided part of the scientific background for the policy recommendations in the World Bank policy research report *Assessing Aid* (World Bank, 1998). The basic result was that aid spurs growth but only in countries with suffiently good macroeconomic performance. This influence of policy on the marginal impact of aid on growth was introduced in regressions via an interaction term between aid and a policy index, later referred to as the Burnside and Dollar policy index.

In many ways the Burnside and Dollar model defined the battleground in terms of control and policy variables, therefore we recast the Burnside and Dollar results in Table 1, regressions (1) and (2).[7]

The dependent variable is the average growth rate in real GDP per capita over six four-year epochs, starting in 1970–73 and ending with 1990–93. The first control variable is the logarithm of initial GDP per capita. The next three controls, ethnic fractionalisation, assassinations and the product of the two, are included to control for the impact of political instability. The number of assassinations vary over time while ethnic fractionalisation is time invariant. Next, institutional quality

[7] The data set is from Burnside and Dollar (2000).

Table 1

Aid-growth Regressions With and Without Geograpical Interaction

Estimation method	(1) OLS	(2) OLS	(3) 2SLS	(4) OLS	(5) OLS	(6) 2SLS
Initial GDP per capita (log)	−0.55	−0.60	0.01	−0.50	−0.54	−0.06
	(0.95)	(1.02)	(0.02)	(0.90)	(0.96)	(0.07)
Ethnic fract.	−0.43	−0.43	0.58	0.12	0.12	1.03
	(0.57)	(0.58)	(0.59)	(0.16)	(0.16)	(1.08)
Assassinations	−0.45*	−0.45*	−0.45*	−0.39	−0.38	−0.37
	(1.66)	(1.68)	(1.70)	(1.55)	(1.55)	(1.58)
Assassinations × Ethnic fract.	0.80*	0.79*	0.88*	0.71*	0.70	0.72*
	(1.75)	(1.75)	(1.92)	(1.65)	(1.63)	(1.69)
Institutional quality	0.67**	0.69**	0.87**	0.659**	0.69**	0.80**
	(3.79)	(3.93)	(3.86)	(3.73)	(4.02)	(3.77)
M2/GDP, lagged	0.02	0.01	0.01	−0.01	−0.02	−0.02
	(1.11)	(0.82)	(0.45)	(0.92)	(1.54)	(0.96)
Sub-Saharan Africa	−1.86**	−1.89**	−3.00**	−1.60**	−1.58**	−2.67**
	(2.44)	(2.43)	(3.32)	(2.10)	(2.04)	(3.09)
East Asia	1.21**	1.32**	1.33**	1.42**	1.57**	1.95**
	(2.03)	(2.22)	(2.01)	(2.36)	(2.63)	(2.94)
Burnside-Dollar policy index	0.78**	0.71**	0.96**	0.86**	0.78**	0.83**
	(3.77)	(3.60)	(6.27)	(4.26)	(4.05)	(5.67)
Aid (EDA/GDP %)	0.05	−0.02	1.35**	1.54**	1.49**	2.47**
	(0.40)	(0.10)	(2.55)	(4.07)	(3.92)	(4.15)
Aid × policy index	0.20**	0.18**		0.05	0.09	
	(2.05)	(2.58)		(0.05)	(1.34)	
Aid squared × policy index	−0.02**			−0.01		
	(2.18)			(0.60)		
Aid squared			−0.13**			−0.10*
			(2.61)			(1.94)
Fraction of land in tropics				−0.62	−0.70	−1.47**
				(1.16)	(1.32)	(2.14)
Aid × fract. of land in tropics				−1.49**	−1.52**	−1.34**
				(3.84)	(4.02)	(2.19)
Test of orthogonality/exogeneity (p-values)						
Aid regressors			0.03			0.04
Lagged aid instruments			0.92			0.95
All overidentifying restrictions			0.83			0.98
Partial R^2 in the first stage regressions†						
Aid			0.53			0.65
Aid squared			0.46			0.44
Aid × fract. of land in tropics						0.64
Observations	275	270	223	275	270	223
Countries	56	56	56	56	56	56
Root MSE	2.89	2.88	3.02	2.80	2.78	2.93

Notes: The dependent variable is real per capita GDP growth. All regressions include time dummies. Robust t-statistics in parentheses. Instruments in regression (5): Aid, Aid squared and aid × policy, all lagged one period, Franc Zone dummy, policy × initial GDP per capita, policy × (initial GPD per capita squared), policy × log of population. In regression (6) the instrument aid × fraction of land in tropics, lagged is added. *significant at 10%; **significant at 5%. †The partial R^2 from the first stage regressions takes the presence of several endogenous variables into account. See Shea (1997) and Godfrey (1999).

is controlled for using ICRG from Knack and Keefer (1995), while the development of financial markets is taken into account using M2 as a percentage of GDP. The list of standard controls is completed by the two regional dummies for Sub-Saharan Africa and (fast growing) East Asia.

Turning to policy, Burnside and Dollar use three measures to create a simple index of good policy; the budget surplus, inflation and trade openness, where openness is the indicator introduced by Sachs and Warner (1995).[8]

Finally, aid is included in the regressions. Burnside and Dollar use the aid variable constructed by Chang *et al.* (1998) (i.e., 'Effective Development Assistance'). In the regressions aid is given as percentage of GDP.

Regression (1) in Table 1 has two policy interaction terms; aid × policy and aid squared × policy. Regression (2) excludes five observations and restricts the model by excluding the second interaction term. The regressions are identical to Burnside and Dollar (2000), Table 4, OLS-regressions (4) and (5), and as seen we obtain the same results: the impact of aid appears to be a positive function of the level of policy, and – in regression (1) – a negative function of the level of aid. This is the empirical background for the claim that aid only works in a good policy environment.

While numerous writers have over the years suggested that a link between aid and policies might be present, disagreement has always existed about the identification of *exactly which* policies are crucial. Hence, if the three policies emphasised by Burnside and Dollar were robust determinants of the return on aid, this would indeed have been an important discovery. From this perspective, it is disappointing that the above aid effectiveness result did not stand up to closer scrutiny. The studies by Dalgaard and Hansen (2001), Hansen and Tarp (2000, 2001), Hudson and Mosley (2001), Lensink and White (2001) and Lu and Ram (2001) all test an interaction term between the Burnside and Dollar policy index and aid, using either different data sets, different regression specifications or different estimators. They all find the interaction to be statistically insignificant. Moreover, when Easterly *et al.* (2003) re-estimate the exact Burnside and Dollar model using an updated and extended dataset, they also end up concluding that the aid-policy interaction is insignificant. To our knowledge, the only study supporting the Burnside and Dollar interaction term is Collier and Dehn (2001). They include measures of export price shocks in the regression model, but this result appears sensitive to alternative measurements of the export price shocks. To complete the picture some studies actually find a negative interaction effect. In particular, Guillaumont and Chauvet (2001) find a negative interaction effect between aid and policies when they include the interaction between vulnerability and aid. More recently, Harms and Lutz (2003) find that while the impact of aid on private foreign investment is close to zero in countries with an average regulatory burden (their policy indicator of choice) it is significantly *positive* in countries that impose a high regulatory burden.

Based on the theoretical model in Section 1, the difficulty in finding a clear and positive estimate of interaction between policies and aid should not be regarded as an empirical curiosity. The potential complexity of the interaction between aid and 'policy' is also demonstrated, within a modified RCK model, by Dalgaard and Hansen (2001). In their model, aid increases the level of consumption yielding less

[8] The specific weights of each component in the index (6.85, −1.4, 2.16) are based on a growth regression that excludes aid.

socio-political instability, which is good for growth.[9] Government activity is limited to raising taxes and providing public goods. Examples of the latter include a well-functioning court system, public security and so forth. In this example, good policies tend to reduce the ramifications of social unrest. Now, suppose aid only works through reducing instability and suppose government intervention gradually manages to remove the harmful effects of social discontent (i.e., in terms of capital accumulation). In that case, the actions of the government will in fact tend to reduce the return on aid. Nevertheless, government actions are, by themselves, stimulating growth.[10]

We view this as a simple illustration of a more general idea. In practice, aid is likely to affect growth through a host of channels. As a result, the return to aid is likely to be affected by numerous and widely differing policy measures. Some policies may be substitutes for aid inflows (as in the example above), while others are better perceived of as complements. This implies that a composite index of policies may encapsulate some components that enhance the return to aid, while others diminish this impact. In the end, the net effect may well turn out insignificant.

Aside from provoking a heated debate on policy conditionality and selectivity in allocating aid, the Burnside and Dollar analysis also stimulated a series of results about non-linear effects of aid on growth. Indeed, the single most common result in recent empirical studies is that aid has a positive impact on real GDP per capita growth but displays diminishing returns (Dalgaard and Hansen, 2001; Hansen and Tarp, 2000, 2001; Lensink and White, 2001). A possibly related finding is that instability of aid inflows appears to have a negative influence on growth, while the level of inflows has a positive impact (Lensink and Morrissey, 2000).

Regression (3) in Table 1 illustrates the diminishing returns result as it was given in Dalgaard and Hansen (2001, Table 4, regression (8)). We have chosen to present this result because it is based on exactly the same data as the Burnside and Dollar regressions. The main difference is that Dalgaard and Hansen use 2SLS with a different set of instruments compared to the 2SLS regressions in Burnside and Dollar (2000).[11] As seen, the regression indicates that there are diminishing returns to aid, as the variable 'aid squared' enters with a significant, negative parameter. Importantly, the study by Dalgaard and Hansen performs a general-to-specific test which ultimately lends unique support to the 'diminishing returns' specification.

Finally, we take a first pass at assessing the importance of (non-political) structural charactaristics on aid effectiveness. This is done by adding the fraction of land in the tropics and the product of this variable and aid. The motivation for using this climate-related variable should be clear from the work of Bloom and Sachs (1998), Gallup *et al.* (1999) and Sachs (2001, 2003) who all show that geography, in the form of tropical land area, tropical diseases (malaria) or being

[9] The basic idea that foreign aid may buy political stability was suggested long ago by Chenery and Strout (1966).

[10] See also Harms and Lutz (2003) who provide another theoretical argument for the negative policy/aid interaction.

[11] We discuss endogeneity of aid and policies in detail below.

landlocked, significantly influences growth in GDP per capita from 1965 to 1990. From this, one may infer that climatic variables appear to represent structural charactaristic with direct bearing on the growth process. Still, an alternative view is that 'geography' rather proxies for other (endogenous, but low frequency) structural charactaristics. As already mentioned, Acemoglu *et al.* (2001) offer an alternative explanation by relating geography to the nature of institutions created by European settlers and Easterly and Levine (2003) find evidence that the geographic endowments affect development only through institutions. Thus, although the precise channels through which geography impacts on growth are currently an area of debate, the exogeneity of tropical land area would appear unquestionable over the time horizon in question in the aid effectiveness and allocation debate.

Regressions (4) and (5) thus augment the Burnside and Dollar models by the above mentioned variables: the fraction of land in the tropics and an interaction term involving aid. The result is that the much discussed interaction between aid and policy once more becomes statistically insignificant, while aid and the interaction between aid and the fraction of land in the tropics are both highly significant. Aid has a strong positive impact on growth outside the tropical region, while the impact is much smaller in the tropics. In regression (6) we test the Dalgaard-Hansen specification. When we add the interaction between aid and the fraction of land in the tropical region in regression (6), the squared term becomes only marginally significant while the interaction between aid and the tropics is, once again, highly significant.[12]

In sum, when we augment two of the competing models of aid effectiveness by a climate dependent impact of aid there is a statistical preference for the climate related specification. This result may, of course, be due to some form of misspecification of the model. The problem that first comes to mind is the possible endogeneity, not only of aid, but also of policies and institutions.

2.1. *Endogeneity and Aid Regressions*

Endogeneity of aid in the growth regression has been recognised and discussed at least since Papanek (1972), and almost all of the recent aid effectiveness studies test for biases in the estimated parameters resulting from endogeneity of aid. Most studies accept the null of valid inference form OLS regressions, with Dalgaard and Hansen (2001) as the exception.[13] The recent debate about the growth impact of institutions has added policies and institutions to the list of (potentially) endogenous regressors.

[12] In addition to the results shown in Table 1 we have also tested the significance of the climate related interaction in the full model, including both the aid policy interactions and aid squared using different estimators (OLS, and robust regression) and with varying samples (including and excluding outliers in the regressor space). The results are that the climate related interaction is significant while the policy interactions and the squared aid term are insignificant.

[13] However, all of the studies test for endogeneity of aid using some version of the Durbin-Wu-Hausman test under the maintained assumption of conditional homoscedasticity. The problem is that the limiting distributions of these tests are not always as we expect if there is conditional heteroscedasticity in the errors.

One may wonder whether the endogeniety of aid, in practice, is much of a problem. If aid allocations are based on past income levels, which may not be good predictors of future growth in poor places, it seems likely that the (classical) endogeniety of aid with respect to growth is a relatively minor problem. However, there is another reason why it is important to treat aid as an endogenous regressor in any cross-country study: Once time-averages are employed for aid and growth, the two will be jointly endogenous.

To see this, consider a simple stylised system of equations for growth, g, aid, a, and policies, p, based on annual observations where subscript i indexes countries and t indexes time.

$$g_{it} = \mathbf{z}_{1i}\boldsymbol{\alpha}_1 + \mathbf{x}_{1it}\boldsymbol{\beta}_1(\mathrm{L}) - \theta_{11}y_{it-1} + \theta_{12}(\mathrm{L})a_{it} + \theta_{13}(\mathrm{L})p_{it} + \varepsilon_{it}^{g}, \tag{6a}$$

$$a_{it} = \mathbf{z}_{2i}\boldsymbol{\alpha}_2 + \mathbf{x}_{2it}\boldsymbol{\beta}_2(\mathrm{L}) - \theta_{21}y_{it-1} + \theta_{23}(\mathrm{L})p_{it} + \varepsilon_{it}^{a}, \tag{6b}$$

$$p_{it} = \mathbf{z}_{3i}\boldsymbol{\alpha}_3 + \mathbf{x}_{3it}\boldsymbol{\beta}_3(\mathrm{L}) + \theta_{31}y_{it-1} + \theta_{32}(\mathrm{L})a_{it} + \varepsilon_{it}^{p}, \tag{6c}$$

The three equations include $1 \times Q_j$ vectors of time invariant controls, $\mathbf{z}_{ji}$, and $1 \times K_j$ vectors time varying controls, $\mathbf{x}_{jit}$, $j = 1, 2, 3$. Some of the controls may be common to all equations but we assume that the system is identified. The time varying controls are assumed to have a finite distributed lag impact on the response variables. This is indicated by the use of m_jth-order lag polynomials, $\boldsymbol{\beta}_j(\mathrm{L})$, $j = 1, 2, 3$, where L is the lag operator such that, say, $\mathbf{x}_{jit}\boldsymbol{\beta}_j(\mathrm{L}) = \sum_{s=0}^{m_j} \mathbf{x}_{jit-s}\boldsymbol{\beta}_{j,s}$.

Equation (6a) is the growth equation, where g_{it} is the annual growth rate of GDP per capita. The vector $\mathbf{z}_i$ contains slow moving variables such as climate, ethnolinguistic fractionalisation etc, whereas $\mathbf{x}_{it}$ contains more volatile variables, like M2/GDP. In (6a) we emphasise the impact of initial GDP per capita (in logs), y_{it-1}, aid, a_{it}, and policies, p_{it} (which for simplicity is modelled as a single variable). Interaction terms are not introduced explicitly in the equation, as this is not essential for our discussion of endogeneity issues.

Equation (6b) is a model of aid allocation. The vectors of control variables $\mathbf{z}_{2i}$ and $\mathbf{x}_{2it}$ capture, respectively, historical and political factors, such as colonial past, support in UN voting, and indicators of recipient needs like infant mortality and educational attainment. These indicators and factors have been stressed in many aid allocation studies. As in the growth equation we single out the possible impact of per capita income and policies, although the impact of both may be zero. However, the vast majority of the recent aid allocation studies have found a significant negative impact of lagged income on aid commitments and disbursements, in accordance with the overriding goal of poverty alleviation (Dudley and Montemarquette, 1976; Trumbull and Wall, 1994; Alesina and Dollar, 2000; Berthélemy and Tichit, 2002).

The third equation (6c) is the equation for policy. The purpose of including a policy equation is first of all to show that aid and policy may be jointly endogenous even if they have no direct influence on each other ($\theta_{23}(\mathrm{L}) = \theta_{32}(\mathrm{L}) = 0$) and, second, to illustrate how we take into account that policy may depend on institutions. Hence, the important aspects of the equation for policy are the possible impacts of the level of income and of institutions.

The system is formulated such that, if the three error terms, ε_{it}^{g}, ε_{it}^{a} and ε_{it}^{p}, are uncorrelated with the regressors and with each other, then the parameters of the growth regression are consistently estimated by ordinary least squares. In other words, if $\text{cov}(\varepsilon_{it}^{g}, \varepsilon_{it}^{a}) = 0$, there is no classical endogeneity problem. The identifying assumption is the recursive structure of the system, i.e., that aid allocation and policy reacts on past income.

However, cross-country growth regressions, like the ones in Table 1, are based on time-averaged data. Appendix B shows that the three equations in (6), when averaged over T years, can be stated in the following way:

$$g_{i\tau} = \mathbf{z}_{1i}\boldsymbol{\alpha}_1\psi + \mathbf{x}_{1i\tau}\boldsymbol{\beta}_1\psi - \theta_{11}\psi y_{i0} + \theta_{12}\psi a_{i\tau} + \theta_{13}\psi p_{i\tau} + \psi\varepsilon_{i\tau}^{g} + v_{i\tau}^{g}, \tag{7a}$$

$$a_{i\tau} = \mathbf{z}_{2i}\boldsymbol{\alpha}_2 + \mathbf{x}_{2i\tau}\boldsymbol{\beta}_2 - \theta_{21}\frac{1}{2}(T-1)g_{i\tau} - \theta_{21}y_{i0} + \theta_{23}p_{i\tau} + \varepsilon_{i\tau}^{a} + v_{i\tau}^{a}, \tag{7b}$$

$$p_{i\tau} = \mathbf{z}_{3i}\boldsymbol{\alpha}_3 + \mathbf{x}_{3i\tau}\boldsymbol{\beta}_3 + \theta_{31}\frac{1}{2}(T-1)g_{i\tau} + \theta_{31}y_{i0} + \theta_{32}a_{i\tau} + \varepsilon_{it}^{p} + v_{i\tau}^{p}. \tag{7c}$$

In this system all variables are averages over T years, $j_{i\tau} = (1/T)\sum_{t=1}^{T} j_{it}$, $j = g$, $\mathbf{x}_k$, a, p, ε_{it}^{g}, ε_{it}^{a}, ε_{it}^{p} for each country, except for y_{i0}, which is initial GDP per capita.

The parameters in (7) are long run parameters in the sense that they are the sums of the distributed lag parameters, say, $\boldsymbol{\beta}_j = \sum_{s=0}^{m_j}\boldsymbol{\beta}_{j,s} \equiv \boldsymbol{\beta}_j(1)$, and $\theta_{jn} = \theta_{jn}(1)$, $j = 1, 2, 3$ and $n = 2, 3$. In addition, there is a common factor in the growth equation (7a), $\psi = T^{-1}[1 - (1 - \theta_{11})^{T}]/\theta_{11}$, which is the conditional correlation between y_{iT} and y_{i0} divided by T to get the impact on the annual growth rate.

Moreover, the system has three new variables $v_{i\tau}^{g}$, $v_{i\tau}^{a}$ and $v_{i\tau}^{p}$. These variables are time-aggregation errors given explicitly in Appendix B. Here we just note that the aggregation errors are in all likelihood heteroscedastic with a (possibly small) moving average component.

In the time averaged system (7) aid and policy both depend on the average rate of growth in GDP per capita even though they are predetermined in the original system. This dependency arises in all time-averaged growth regressions in which the regressor depends on past levels of income, as long as the dependency is within the period over which we average.[14] In other words, we should expect aid and policies to be endogenous regressors in Table 1 if aid allocations and policies depend on real per capita income lagged somewhere between one and three years.

The time-averaged system also shows that it is difficult to test for endogeneity of aid and policies because of the time-aggregation error $v_{i\tau}^{g}$. The error shows that all time varying regressors (i.e., both $\mathbf{x}_{1i\tau}$, $a_{i\tau}$, and $p_{i\tau}$) are potentially correlated with the error term. Unfortunately we cannot compute the magnitude of the bias without specifying the dynamics of all variables in the system. All that can be said is that the aggregation bias is decreasing in T. This means that in the aid-growth regressions there is a trade-off between long averages that minimise the aggregation bias and short averages that minimise the endogeneity bias. Whether four year averages strikes a good balance is quite unknown, and seems difficult to quantify. Yet, it is important to be aware of the problem as tests of endogeneity of aid and

[14] Notice that the convergence parameter, θ_{11}, is irrelevant for this result.

policies have been based on the maintained assumption that the time-varying controls are not (closely) correlated with the aggregation error.

Turning to the problem of finding instruments for aid, the allocation literature provides many good candidates. Unfortunately most of the recipient needs variables, such as infant mortality, are in all likelihood correlated with either growth and/or the level of income and hence are not valid as instruments. At first sight, this seems to only leave the historical and political factors that may not be particularly helpful in the description of total aid inflows to a specific country, as a single aid recipient has many donors. However, the reduced form relation for aid shows that, in the panel setting, lagged aid is highly correlated with current aid. The reduced form is

$$a_{i\tau} = \mathbf{z}_i \boldsymbol{\pi}_{21} + \mathbf{x}_{i\tau} \boldsymbol{\pi}_{22} - \pi_{23} y_{i0} + e_{i\tau}, \tag{8}$$

where $\mathbf{z}_i = [\mathbf{z}_{1i}, \mathbf{z}_{2i}, \mathbf{z}_{3i}]$, $\mathbf{x}_{i\tau} = [\mathbf{x}_{1i\tau}, \mathbf{x}_{2i\tau}, \mathbf{x}_{3i\tau}]$ and $\boldsymbol{\pi}_{21}$, $\boldsymbol{\pi}_{22}$ and π_{23} are the vectors of reduced form parameters.

The time invariant factors introduce a persistent serial correlation in the aid process. This correlation can be used to substitute lagged values of aid for the time invariant factors in the reduced form. Hence, the reduced form can be reformulated to an auto regressive model of aid

$$a_{i\tau} = \omega a_{i\tau-1} + \mathbf{x}_{i\tau} \boldsymbol{\pi}_{22} - \pi_{23} y_{i0} + e_{i\tau}, \qquad \omega = \frac{\mathrm{Var}(\mathbf{z}_i \boldsymbol{\pi}_{21} | \mathbf{x}_i, y_{i0})}{\mathrm{Var}(\mathbf{z}_i \boldsymbol{\pi}_{21} | \mathbf{x}_i, y_{i0}) + \mathrm{Var}(e_{i\tau})}. \tag{9}$$

As not all controls can be included in the reduced form it is probably better to think of the parameter, ω as the ratio of the pure cross-country variation to the total variation in aid, conditional on the time varying regressors. This is a well known ratio in error components models and it shows that one should expect a parameter between zero and one. As the cross country variation in aid is much larger than the (conditional) time series variation we expect a parameter close to unity.

To illustrate the gain from including lagged aid as an instrument in the growth regressions we have estimated the reduced form for aid based on the choice of variables in Burnside and Dollar (2000) and subsequently added lagged aid to this regression. We estimate the reduced forms using two data sets; the original Burnside and Dollar data (BD), and the updated data set compiled by Easterly *et al.* (2003) (ELR). The updated data set includes the same variables and has the same basic structure as the original BD data but the country coverage is larger and the data set includes the recent period 1994–97.

Burnside and Dollar (2000, Tables 1 and 8) single out a few variables such as country and regional indicators (Egypt, Franc Zone countries and Central America), arms imports relative to total imports and the size of the population.[15] As seen from Table 2, regressions (1) and (2), the regional indicators are not particularly helpful in explaining the aid allocation across countries. In fact, only one variable, the size of the population, appears to identify aid allocations.

[15] Larger countries receive relatively less aid per capita and as a fraction of GDP; this is termed 'the small country bias' in the allocation literature.

Table 2

Reduced Form Aid Regressions

Data set	(1) BD	(2) ELR	(3) BD	(4) ELR
Real GDP per capita (log)	−1.81**	−1.37**	−0.72**	−0.50**
	(8.35)	(5.54)	(3.34)	(3.25)
Ethnic fract.	−0.02	−0.66	−0.08	−0.16
	(0.06)	(1.06)	(0.32)	(0.74)
Assassinations	0.19*	0.15	0.13*	0.19*
	(1.79)	(1.40)	(1.77)	(1.72)
Assassinations × Ethnic fract.	−0.34**	−0.18	−0.24*	−0.31
	(2.00)	(0.84)	(1.93)	(1.62)
Institutional quality	0.16	0.02	0.001	0.02
	(1.44)	(0.27)	(0.01)	(0.54)
M2/GDP, lagged	0.02	0.02	0.02	−0.002
	(1.11)	(1.73)*	(0.80)	(0.51)
Sub-Saharan Africa	0.49*	0.09	−0.03	0.14
	(1.73)	(0.20)	(0.14)	(0.68)
East Asia	0.11	0.25	0.16	0.31**
	(0.43)	(0.86)	(0.80)	(2.55)
Policy index†	−0.05	−0.04*	−0.09	−0.04**
	(0.48)	(1.76)	(1.09)	(2.98)
Population (log)	−0.69**	−0.62**	−0.28**	−0.26**
	(6.10)	(5.07)	(3.42)	(3.52)
Arms imports (lagged)	0.02	0.02	0.01	2.01**
	(1.34)	(1.84)*	(1.33)	(2.12)
Egypt	0.62	−0.47	−0.41	−0.15
	(0.83)	(0.58)	(0.46)	(0.66)
Franc Zone countries	0.11	0.30	−0.18	0.08
	(0.25)	(0.72)	(0.55)	(0.35)
Central America	0.01	−0.47	−0.02	−0.11
	(0.05)	(1.06)	(0.08)	(0.55)
Lagged aid			0.83**	0.69**
			(7.31)	(7.88)
Observations	236	318	236	318
Countries	54	62	54	62
R-squared	0.64	0.49	0.82	0.78
F-test of instruments	11.76	7.70	23.72	31.49

Note: The dependent variable is aid as percentage of GDP. All regressions include time dummies. Heteroscedasticity and autocorrelation robust t-statistics in parentheses. *Significant at 10%; **significant at 5%. †The weights forming the policy index are (6.85, −1.4, 2.16) in regressions (1) and (3) and (1.26, −1.91, 2.47) in regressions (2) and (4).

Moreover the F-statistics of instrument relevance in regressions (1) and (2) indicate that the chosen set is on the border of being weak instruments. In particular it is worth noticing that the F-statistic is actually decreasing when we add more data, and below 10 in regression (2). In regressions (3) and (4) we add lagged aid and, as expected from the arguments given above, this improves the fit substantially. Moreover, the F-statistic of instrument relevance is now far above 10 and increasing when we add more data.

One last thing to note about the reduced forms in Table 2 is that aid allocations respond to lagged income. This underlines the importance of modelling aid as an endogenous regressor.

Obviously, lagged aid is not a valid instrument if it is correlated with the time-average error, $v^g_{i\tau}$. Therefore it is important to test for the validity of these instruments (and by implication for serial correlation in the errors). In the 2SLS regressions in Table 1 we specifically test for endogeneity of the lagged aid instruments and, as seen, using the difference-in-criterion function test (or diff-Sargan test), which is robust to heteroscedasticity we do not reject the hypothesis that the lagged aid instruments are uncorrelated with the errors.

The next issue which needs to be addressed is the possible endogeneity of institutions, and the consequences this might have on the identification of the impact of aid on growth.

As is well known, there has been an extensive and innovative search for good instruments for institutions. However, in the present study we are not particularly interested in the impact of institutions on long run growth. Our primary objective is to ensure that the results with respect to the impact of aid on growth are not driven by endogenous differences in institutions. Therefore, instead of using instruments for the historically determined component of institutions – as it is termed by Acemoglu *et al.* (2003) – we simply 'remove' this effect by first differencing (7*a*). Hence, in addition to standard pooled panel GMM-regressions with endogenous aid and policies we will also look at panel GMM-regressions of first differences. The estimator by Arellano and Bond (1991), often denoted DIF-GMM, and the estimator proposed by Blundell and Bond (1998), denoted SYS-GMM, are both frequently used to estimate dynamic panel data models with unobserved heterogeneity. In the present setting they are ideal choices for eliminating the impact of time invariant (and slowly changing) institutions while at the same time accounting for possible endogeneity of aid and policies. In essence, we identify the impact of aid and policies by negation: even though we do not formulate structural models for aid and policies, we do know that the estimated impact in the differenced growth model is not driven by time invariant cross-country variation in institutions.

Turning to the empirical results, Table 3 reports growth regressions in which we pursue the hypothesis that aid's impact is a function of climate related differences across countries.[16] The results in Table 3 are based on the updated and extended data set computed by Easterly *et al.* (2003). The regressions cover up to 65 countries and 6 periods (1974–7 to 1994–7) using data in the period 1970–3 as instruments in the GMM-regressions (2)–(6). In contrast to the regressions in Table 1 we have excluded the measures of political instability (ethnic fractionalisation and assassinations), furthermore we include the three policy measures; budget surplus, inflation and trade openness, individually instead of a policy index.

Moving from left to right in Table 3 we look at the robustness of aid impact when we let more and more regressors be endogenous. In essence we 'gain' robustness in terms of consistency while we 'sacrifice' efficiency in terms of increasing parameter variances.

Starting with regression (1) we find, using pooled OLS, that aid has a positive impact on growth. Across countries the impact is smaller in countries with large fractions of land in the tropics. This result is the same as in Table 1, although the estimated impact is somewhat smaller using the updated data set. In regression (2) we use instruments for aid to assess the possible bias in regression (1). There is a

[16] The regressions in Table 3 were carried out using DPD for Ox. See Doornik *et al.* (2001).

Table 3

Assessing the Impact of Endogeneity of Aid, Policies and Institutions

Estimation method	(1) OLS	(2) GMM	(3) GMM	(4) GMM-DIF	(5) GMM-SYS
Initial GDP per capita (log)	−0.68**	−0.82**	−0.80**	−2.62	−0.93
	(1.99)	(2.22)	(2.04)	(1.42)	(1.07)
Institutional quality	0.43**	0.47**	0.51**		
	(3.32)	(3.67)	(3.68)		
Sub-Saharan Africa	−1.07*	−1.65**	−1.03**		
	(1.87)	(3.38)	(1.97)		
East Asia	2.69**	2.49**	2.41**		
	(3.85)	(3.78)	(3.44)		
Fraction of land in tropics	−1.31**	−1.67**	−1.73**		
	(3.02)	(3.74)	(3.96)		
Budget surplus	0.08	0.08	0.03	0.14	0.13
	(1.28)	(1.33)	(0.31)	(1.18)	(1.30)
Inflation	−1.97**	−2.09**	−1.24**	−2.25	−1.54
	(3.44)	(3.97)	(2.32)	(1.53)	(1.34)
Sachs-Warner openness	0.45	0.48	1.09*	−1.07	0.21
	(0.85)	(1.07)	(1.72)	(0.67)	(0.14)
Aid	0.60**	0.34**	0.33**	1.31**	0.87**
	(4.70)	(3.27)	(2.66)	(8.99)	(4.86)
Aid × fract. of land in tropics	−0.77**	−0.48**	−0.50**	−2.01**	−1.52**
	(3.10)	(2.40)	(2.51)	(3.65)	(3.89)
Impact of aid in the tropics	−0.17	−0.13	−0.17	−0.70	−0.65**
	(1.37)	(1.03)	(1.30)	(1.45)	(1.98)
Test of residual autocorrelation					
First order	0.48	0.44	0.50	−3.19**	−3.11**
	[0.63]	[0.66]	[0.62]	[0.00]	[0.00]
Second order	1.56	1.39	1.31	1.30	1.30
	[0.12]	[0.16]	[0.19]	[0.20]	[0.19]
Hansen J-test (p-value)		0.13	0.48	1.00	1.00
Partial R^2 in the first stage regressions					
Aid		0.72	0.62		
Aid × fract. of land in tropics		0.71	0.68		
Budget surplus			0.26		
Inflation			0.43		
Sachs-Warner openness			0.48		
Observations	332	316	303	306	361
Countries	65	65	63	63	63
Root MSE	3.02	3.03	3.04	3.06	3.20

Notes: The dependent variable is real per capita GDP growth. All regressions include time dummies. Robust t-statistics in parentheses. The t-statistics inregressions (4) and (5) are based on small sample corrected covariance estimates; see Windmeijer (2000). Instruments in regression(2): Aid, aid squared, aid × inflation, aid × openness, aid × fraction of land in tropics, M2/GDP, all lagged one period, and log(population). In regression (3) the instruments Budget surplus, inflation and openness, all lagged one period, are added. Regression (4) adds all possible lags of real per capita GDP growth and initial GDP per capita and includes all available lags of the instruments used in regressions (3) and (4). *significant at 10%; **significant at 5%.

fairly large drop in the estimated impact of aid but the impact is still highly significant (outside the tropics). Moving to regression (3) we add the three policy measures to the list of endogenous regressors, using the lagged values as instruments. This change has virtually no influence on the estimated impact of aid.

In regressions (4) and (5) we remove the impact of institutions and other time invariant factors by differencing. We apply the 'standard' set-up for the two

GMM-estimators, i.e., we use all possible lagged levels of growth and of the regressors as instruments. Endogenous regressors are lagged at least twice while predetermined regressors are lagged at least once.

Removing the impact of time invariant factors has a rather large influence on the estimated impact of aid compared to the first three regressions. Outside the tropics a one percentage point increase in the aid/GDP ratio leads to an increase in the growth rate in the neighbourhood of one percentage point. In the tropics the result is unchanged compared to the level regressions; the estimated impact is not significantly different from zero.

As the finite sample bias in GMM-parameter estimates is increasing in the number of moment conditions we experimented with the number of instruments in regressions (4) and (5). While there are some changes in the results, the estimated impact of aid is unchanged when we limit the use of instrument lags and the impact is also robust to inclusion of the measures of political instability.[17]

The overriding result of the regressions is a surprising constancy of the impact of aid on growth and of the statistical significance of the impact. For comparison one could look at the estimated impact of the policy measures that are either insignificant throughout (the budget surplus) or changing from statistically significant in the level regressions (1)–(3), to insignificant in the difference regressions (4) and (5) (inflation). Moreover, when the regressions are based on the original Burnside and Dollar data we obtain qualitatively the same results, although the estimated impact of aid is somewhat larger and more constant across estimators.[18] Therefore we have confidence in the claim that aid has a positive impact on growth, and that the impact depends on climate related differences.

In the next Section we discuss the implications of our results for the aid allocation rule advocated in Collier and Dollar (2001).

3. The Collier-Dollar Aid Allocation Rule

In recent research Collier and Dollar (2001, 2002) invigorate the policy debate by introducing the World Bank Country Policy and Institutional Assessment index (CPIA) in growth regressions. They show that an interaction term between aid and CPIA has a highly significant, positive effect, bringing us back to the claim that aid spurs growth in a good policy environment. Moreover, Collier and Dollar take a second, logical although not innocuous, step as they formulate an 'optimal' aid allocation rule based on the growth regressions. Collier and Dollar (2001) assert that a combination of policy reform in Africa (improvements in the CPIA index) and an optimal aid allocation, will enable the world society to cut poverty in half by 2015.

The basic message is that countries with low income per capita (poverty) and a high CPIA score should be eligible for aid, while countries with a low CPIA score should not be eligible for aid, or alternatively should receive less aid. This idea has

[17] In contrast the results for trade openness and inflation are highly sensitive to the choice of instruments and sample.

[18] The results are available from the authors on request.

been adopted by IDA and the British aid organisation DFID.[19] Hence, in a very short time the Collier-Dollar model has moved from an academic idea (with a strong policy message) to something very concrete in the donor community.

While we have nothing against aid allocation rules as such we question the usefulness of introducing CPIA in growth regressions and we seriously doubt if the CPIA score should have anything to do with the actual aid allocation.

Our concerns regarding the CPIA index are threefold: (i) because of the construction of the CPIA index, there is little to be learned from this index in terms of growth performance in the first place, (ii) the changes in the CPIA index over time may well be 'caused' by the growth performance, in which case CPIA should not be used as an exogenous variable in allocation models, and (iii) the use of the CPIA index in allocation models may lead us to punish countries with unfavourable initial conditions instead of helping them, because we confuse climate related problems with poor CPIA ratings and 'unwillingness to reform'. In what follows we will elaborate on each of these objections.

In terms of using the CPIA in growth (and poverty) regressions we find that the lessons to be learnt from the positive interaction term between aid and CPIA are in reality hard to pinpoint. The strength of the original Burnside and Dollar hypothesis was the claim that a small set of policies could be singled out as crucial. The CPIA index, on the other hand, assesses the quality of a country's present policy and institutional framework in 20 different dimensions.[20] Thus, in terms of drawing-up clear-cut recommendations for policy makers on how to enhance the effectiveness of aid, the analysis is not particularly helpful. Trade-offs between elements of the index are bound to arise in practice. For example, placing greater emphasis on budget balance (a component of 'Economic Management') could conceivably be in conflict with improving access to health care, education etc. (the component 'Building Human Resources' which belongs to the general group of 'Policies for Social Inclusion/Equity'). In particular, it might very possibly lower the 'pro-poor expenditure index' shown to be poverty-reducing by Mosley *et al.* (2004).

Our second concern is endogeneity. As already mentioned there is ample evidence, that policies and growth are jointly endogenous variables. For example, Clague *et al.* (1996) and Mauro (1995) argue that good economic performance increases institutional efficiency. In relation to the CPIA index it is more interesting that Mauro goes on to highlight that using expert evaluations may be problematic, the argument being that an evaluator is likely to conclude that a particular set of institutions is good if the country in question is growing rapidly.

Unfortunately, it is currently impossible to investigate directly whether endogeneity of the CPIA index is an issue, as the data are not in the public domain. However, indirect evidence does shed light on what further analyses are likely to find.

[19] See the World Bank homepage and Dyer *et al.* (2003).

[20] These 20 items are assessed by World Bank experts on a scale from 1 to 6 (measuring 'unsatisfactory for an extended period' to 'good for an extended period'). Each item has a 5% weight in the overall rating. The items are grouped into four categories: 'Economic Management', 'Structural Policies', 'Policies for Social Inclusion/Equity' and 'Public Sector Management and Institutions'.

We obtained data on CPIA in 1999 and 2001 from *News and Notices for IMF and World Bank Watchers*, Vol. 2, No. 3, 2000 and No. 6, 2002. Even though this is not exactly the World Bank CPIA data, it would appear to be capable of providing a pretty good indication of the concordance between the CPIA and publicly available data.

In Table 4, we report regressions of the CPIA rating in 2001 using the rating in 1999 and the growth rate in real GDP per capita from 1999 to 2000 as regressors.[21] We expect the ratings to be very persistent; as policies and institutions are persistent. Therefore we find it all the more interesting that the growth rate in GDP in a single year is able to improve a forecast of the ratings for 2001 when we control for the ratings in 1999. Moreover, the rate of growth seems to have explanatory power and approximately the same impact on all four sub-groups of the overall index.

Needless to say, the findings of Granger causality in Table 4 are only indicative. However, they are supported by the study by Chong and Calderon (2000) in which it is shown that changes in the ICRG index are Granger caused by economic growth. This result is relevant in the present context because there is a significant positive correlation between the ICRG index and our data for CPIA index.

To be sure, these insights do not *per se* invalidate the regression results in Collier and Dollar (2001, 2002). However, they do justify a certain amount of scepticism regarding the policy relevance and appropriateness of using these regressions in counter-factual scenarios such as re-allocation of aid based on good CPIA ratings. If the CPIA index is Granger-caused by growth it should not be used as an exogenous variable in forecasts and policy simulations. This rather obvious, and well known, result is unfortunately not discussed neither in Collier and Dollar (2001, 2002) nor in the documents by IDA and DFID.

Our third concern is in our view the most serious problem with the Collier-Dollar allocation rule. In essence it amounts to a simple identification problem but it has far reaching consequences for the optimality of the allocation rule.

Table 5 reports the rank correlations between the CPIA index and each of its sub-groups in 2001 with the fraction of land in the tropics – the variable we used in the growth regressions in the previous Section. As seen, there is a very high probability that a country having a low CPIA score is in the tropical region. Hence,

Table 4
Forecasting the CPIA Ratings in 2001

	Overall Index	Economic Management	Structural Policies	Social Inclusion	Public sector Management
CPIA rating in 1999	0.80	0.70	0.79	0.81	0.77
	(11.95)	(8.01)	(12.36)	(12.77)	(10.89)
Growth rate 1999–00	0.05	0.05	0.07	0.03	0.05
	(2.78)	(3.09)	(3.76)	(1.81)	(2.82)

Notes: The dependent variable is the CPIA rating in 2001 for 67 countries. Robust t-statistics in parentheses. The CPIA ratings are obtained from *News and Notices for IMF and World Bank Watchers*, Vol. 2., No. 3, 2000 for the 1999 ratings and No. 6, 2002 for the 2001 ratings.

[21] The growth rate is calculated from the PPP-adjusted real GDP per capita available from the WDI 2002 CD-ROM.

Table 5

Rank Correlations Between the Fraction of Land in the Tropics and the CPIA Index in 2001

	Overall Index	Economic Management	Structural Policies	Social Inclusion	Public sector Management
Fraction of land in tropics	−0.37	−0.40	−0.21	−0.38	−0.14
	[0.00]	[0.00]	[0.11]	[0.00]	[0.25]

Notes: Spearman rank correlations with *p*-values for test of independence in brackets.The correlations are based on 61 observations. The CPIA gradings for 2001 are obtained from *News and Notices for IMF and World Bank Watchers*, Vol. 2, No. 6, Spring 2002.

the positive interaction between aid and CPIA obtained in Collier and Dollar (2001, 2002), may well be caused by the low impact of aid in the tropical region.

If one accepts that the impact of climate on growth is (mainly) through institutions, then we are just stating that Collier and Dollar should instrument the CPIA index in the growth regressions, and we have shown that the fraction of land in the tropics is in all likelihood a good instrument.

However, when the CPIA ratings are used in 'optimal' allocation models, then there is a considerable risk that we punish countries with climate related problems when we 'support the good performers' (high CPIA) to maximise the global economic growth rate.

Hence, ultimately the core question may boil down to this: should we stop giving aid to countries in the tropics? Undoubtedly, these are countries which have displayed dismal growth performance in the last several decades, and in addition, aid seems to have been far less effective in such regions. Certainly, if the Collier-Dollar allocation rule is used indiscriminately, this will be the result.

4. Conclusion

The need for growth and development is as great as ever if we are to come even close to the United Nations target of halving world poverty by 2015. The central message of the present paper is that aid can play a conducive role in reaching such a target. Our results show that, in many countries, aid has had a significant positive impact on productivity. At the same time it should be recognised that aid is not a panacea for poverty reduction. Ultimately, aid in itself will not ensure convergence but it can stimulate the process. These conclusions are, we believe, commonly accepted among academics working on the topic.

At this stage the key question to be settled is why aid works so much better in some countries compared with others. While we find the evidence in favour of a strong interaction between policy and aid weak, our empirical work reveal a disturbing and rather robust pattern: Over the last thirty years, aid seems to have been far less effective in tropical areas. It is very hard to believe that aid, inherently, should be less potent in the tropics. Hence the explanation is likely to be found elsewhere. Perhaps tropical areas have particular needs in ways of foreign assistance; needs which may not so far have been met to a sufficient extent? Accounting for the nature of the interaction between climate and aid seems to be a worthwhile topic for future research. Such investigations would surely have to move beyond the reduced-form aid regressions, which so far has dominated the scene. Disentangling the channels through which aid matters for productivity seems to be a crucial research topic at this stage.

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Appendix

A. Details of the Theoretical Model

The law of motion for capital per worker can be written

$$k_{t+1} = \frac{s[w(k_t), r(k_{t+1}); z]}{1+n}, \ \ k_0 \text{ given.}$$

From Lemma 1 in Galor and Ryder (1989) it follows that given $k_t > 0$ there exists a unique $k_{t+1} > 0$ that is a self-fulfilling expectation, since $s_{r_{t+1}} > 0$ for all r_{t+1}. This is straight forward to check, using (2). By implication there exists a single-valued function ϕ such that we can express the law of motion for capital: $k_{t+1} = \phi(k_t)$. Moreover, note that $\phi(0) = \bar{k} > 0$, where

$$\bar{k} : \bar{k} - \frac{\sigma}{1+n}\left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(\bar{k})}\right]\pi^y x = 0.$$

Next, observe that

$$\frac{\partial k_{t+1}}{\partial k_t} = \frac{\frac{\sigma}{(1+n)}w'(k_t)}{1 - \frac{\sigma}{1+n}\frac{\pi^o}{\pi^y}\frac{(1+\rho)r'(k_{t+1})}{[1+r(k_{t+1})]^2}\pi^y x} > 0 \ \forall k,$$

since $w'(k) > 0$ and $r'(k) < 0$. Thus $\phi'(k_t) > 0 \ \forall k$.

The second derivative $\phi''(k_t)$ is in general ambigious – it depends on the third derivative of the underlying production function – hence multiple equilibria cannot be ruled out *a priori*. However, *assuming* $\phi''(k_t) < 0$ for all k, and in light of the fact that $s(k_t, k_{t+1};z)$ is bounded from above, we way conclude that a steady state exists, is unique, and fulfills:

$$k^* = \frac{\sigma}{1+n}\left\{w(k^*) + \left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(k^*)}\right]\pi^y x\right\}.$$

Finally, to show that the sign of $\left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(k*)}\right]$ determines whether aid is effective or not, we start by noting that

$$\frac{\partial k^*}{\partial x} = \frac{\frac{\sigma}{1+n}\left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(k^*)}\right]\pi^y}{1 - \frac{\sigma}{1+n}\left[w'(k^*) + \left(\frac{\pi^o}{\pi^y}\right)\frac{(1+\rho)r'(k^*)}{1+r(k^*)}\pi^y x\right]}.$$

Evaluated near steady state the denominator is unambigiously positive. This follows from the fact that

$$\frac{\partial k_{t+1}}{\partial k_t}_{|k_{t+1}=k_t=k^*} < 1,$$

which implies that the following holds near steady state:

$$\frac{\sigma}{1+n}w'(k^*) < 1 - \frac{\sigma}{1+n}\frac{\pi^o}{\pi^y}\frac{(1+\rho)r'(k^*)}{[1+r(k^*)]^2}\pi^y x$$

$$\Updownarrow$$

$$1 - \frac{\sigma}{1+n}w'(k^*) - \frac{\sigma}{1+n}\frac{\pi^o}{\pi^y}\frac{(1+\rho)r'(k^*)}{[1+r(k^*)]^2}\pi^y x > 0.$$

Hence, $\text{sign}\left(\frac{\partial k^*}{\partial x}\right) = \text{sign}\left[1 - \left(\frac{\pi^o}{\pi^y}\right)\frac{1+\rho}{1+r(k*)}\right].$

B. The Time Averaged System of Equations

B.1. *The Growth Equation*

The growth equation (6*a*) is an autoregressive distributed lags model for the log of income per capita. For ease of notation we gather the time varying regressors in $\mathbf{w}_{it} = [\mathbf{x}_{it}, a_{it}, p_{it}]$ and stack $\boldsymbol{\beta}_1(\text{L})$, $\theta_{12}(\text{L})$ and $\theta_{13}(\text{L})$ in $B(\text{L})$, where we let m denote the maximum power of the lag polynomial. Defining $\rho = 1 - \theta_{11}$, we can write the growth equation as

$$y_{it} = \mathbf{z}_i\boldsymbol{\alpha}_1 + \mathbf{w}_{it}B(\text{L}) + \rho y_{it-1} + \varepsilon^g_{it}. \tag{10}$$

Using the decomposition

$$\mathbf{w}_{it}B(\text{L}) = \mathbf{w}_{it}B + \Delta\mathbf{w}_{it}B^*(\text{L})$$

where $\Delta = 1 - \text{L}$ is the difference operator and $B = B(1) = \sum_{j=1}^m B_j$, $B^*_k = -\sum_{s=k+1}^m B_s$, $k = 0,\ldots, m-1$, we can reformulate the growth equation and gather the total impact ($B(1)$) in a single parameter matrix

$$y_{it} = \mathbf{z}_i\boldsymbol{\alpha}_1 + \mathbf{w}_{it}B + \Delta\mathbf{w}_{it}B^*(\text{L}) + \rho y_{it-1} + \varepsilon^g_{it}. \tag{11}$$

The moving average representation for y_{iT} conditional on y_{i0} (initial income per capita) can now be given as

$$y_{iT} = \mathbf{z}_i\boldsymbol{\alpha}_1\tilde{\psi} + \rho^T y_{i0} + \sum_{s=0}^{T-1}\rho^s\left[\mathbf{w}_{iT-s}B + \Delta\mathbf{w}_{iT-s}B^*(\text{L}) + \varepsilon^g_{iT-s}\right], \tag{12}$$

where $\tilde{\psi} = (1-\rho^T)/(1-\rho)$.

Let the averages of $\mathbf{w}_{it}$ and ε^g_{it} over the T periods be $\mathbf{w}_{i\tau} = \frac{1}{T}\sum_{t=1}^T \mathbf{w}_{it}$, $\varepsilon^g_{i\tau} = \frac{1}{T}\sum_{t=1}^T \varepsilon^g_{it}$. Add and subtract these averages

$$\begin{aligned} y_{iT} &= \mathbf{z}_i\boldsymbol{\alpha}_1\tilde{\psi} + \mathbf{w}_{i\tau}B\tilde{\psi} + \rho^T y_{i0} + \varepsilon^g_{i\tau}\tilde{\psi} \\ &\quad + \sum_{s=0}^{T-1}\rho^s\left[(\mathbf{w}_{iT-s} - \mathbf{w}_{i\tau})B + (\varepsilon^g_{iT-s} - \varepsilon^g_{i\tau}) + \Delta\mathbf{w}_{iT-s}B^*(\text{L})\right]. \end{aligned} \tag{13}$$

Subtract y_{i0} from both sides and divide by T to get the (log approximation of) the average nnual growth rate in GDP per capita over the period $t = 1,\ldots, T$; $g_{i\tau} = \frac{1}{T}(y_{iT} - y_{i0})$, then

$$g_{i\tau} = \mathbf{z}_i\boldsymbol{\alpha}_1\psi + \mathbf{w}_{i\tau}B\psi - \psi\theta_{11}y_{i0} + \varepsilon^g_{i\tau}\psi + v^g_{i\tau}, \tag{14}$$

where

$$\psi = \frac{1}{T}\frac{1-\rho^T}{1-\rho} = \frac{1}{T}\frac{1-(1-\theta_{11}^T)}{\theta_{11}}$$

and

$$v_{i\tau}^{g} = \frac{1}{T}\sum_{s=0}^{T-1}\rho^{s}\left[(\mathbf{w}_{iT-s} - \mathbf{w}_{i\tau})B + (\varepsilon_{iT-s}^{g} - \varepsilon_{i\tau}^{g}) + \Delta\mathbf{w}_{iT-s}B^{*}(\mathrm{L})\right] \tag{15}$$

is the time-average error in the growth equation.

Inserting the definition of $\mathbf{w}_{it}$ in (14) we obtain (7*a*).

B.2. *The Equations for Aid and Policy*

The equations for aid and policy have similar mathematical structures. Therefore it suffices to show the time-aggregation for one of the equations. Here, it is the aid allocation equation.

Let $\mathbf{v}_{it} = [\mathbf{x}_{2it}, p_{it}]$ and stack $\boldsymbol{\beta}_2(\mathrm{L})$ and $\theta_{23}(\mathrm{L})$ in $C(\mathrm{L})$, which we assume is a m-th order polynomial. Using the same decomposition in levels and changes for $\mathbf{v}_{it}$ as the one used for $\mathbf{w}_{it}$, the aid allocation equation can be written

$$a_{it} = \mathbf{z}_{2i}\boldsymbol{\alpha}_2 + \mathbf{v}_{it}C + \Delta\mathbf{v}_{it}C^{*}(\mathrm{L}) - \theta_{21}y_{it-1} + \varepsilon_{it}^{a}. \tag{16}$$

Averaging over T years, we have

$$a_{i\tau} = \mathbf{z}_{2i}\boldsymbol{\alpha}_2 + \mathbf{v}_{i\tau}C + \varepsilon_{i\tau}^{a} + \frac{1}{T}\sum_{t=1}^{T}[\Delta\mathbf{v}_{it}C^{*}(\mathrm{L}) - \theta_{21}y_{it-1}]. \tag{17}$$

The average of lagged income per capita can be reformulated as

$$\begin{aligned}\frac{1}{T}\sum_{t=1}^{T}y_{it-1} &= \frac{1}{T}\sum_{t=1}^{T-1}\Delta y_{it} + \frac{1}{T}\sum_{t=2}^{T}(T-t)\Delta y_{it-1} + y_{i0}\\ &= g_{i\tau} - \frac{1}{T}\Delta y_{iT} + \frac{1}{T}\sum_{t=1}^{T-1}(T-t-1)\Delta y_{it} + y_{i0}\\ &= \frac{1}{2}(T-1)g_{i\tau} + \frac{1}{T}\sum_{t=1}^{T-1}(T-t-1)(g_{it} - g_{i\tau}) + y_{i0}\end{aligned}$$

where $g_{i\tau} = \frac{1}{T}(y_{iT} - y_{i0})$ and $g_{it} = (y_{it} - y_{it-1})$.

The average of the annual changes in $\mathbf{v}_{it}$ can be given as

$$\frac{1}{T}\sum_{t=1}^{T}\Delta\mathbf{v}_{it}C^{*}(\mathrm{L}) = \sum_{s=0}^{m-1}\frac{1}{T}\Delta_{T}\mathbf{v}_{iT-s}C_{s}^{*} \tag{18}$$

where $\Delta_T = 1 - \mathrm{L}^T$ such that $\frac{1}{T}\Delta\mathbf{v}_{iT-s}$ is the average annual change in $\mathbf{v}_i$ from year $-s$ to $T - s$.

Using these results the aid allocation equation averaged over T years becomes

$$a_{i\tau} = \mathbf{z}_{2i}\boldsymbol{\alpha}_2 + \mathbf{v}_{i\tau}C + -\theta_{21}\frac{1}{2}(T-1)g_{i\tau} - \theta_{21}y_{i0} + \varepsilon_{i\tau}^{a} + v_{i\tau}^{a} \tag{19}$$

with

$$v_{i\tau}^{a} = \frac{1}{T}\sum_{t=1}^{T-1}(T-t-1)(g_{it} - g_{i\tau}) + \sum_{s=0}^{m-1}\frac{1}{T}\Delta_{T}\mathbf{v}_{iT-s}C_{s}^{*}. \tag{20}$$

Inserting the definition of $\mathbf{v}_{it}$ in (19) results in (7*b*) in the text.

The time-averaged equation for policy follows directly.

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