



# Estimating aid-growth equations: the case of Pacific island countries

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The seminal but controversial work of Burnside and Dollar (2000) has been the basis for much empirical research on the growth effects of development aid. This article argues that the specifications adopted in these works are not consistent with the data and the statistical techniques used. A modified production function is proposed in which total factor productivity depends on time as well as the aid ratio. Our empirical results show that the effect of aid on the steady state growth rate is insignificant in the selected Pacific island countries. These countries are of interest because they are among the largest recipients of aid in per capita terms.

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There has been considerable interest in the effect of development aid on the growth rates of developing countries. Many econometric works have estimated the aid-growth relationship following the seminal but controversial work of Burnside and Dollar (2000), which found that aid is more growth effective in countries that meet the conditionality conditions of the large development agencies such as the International Monetary Fund (IMF) and World Bank. The main conditionality requirements are good governance and good economic policies, which generally need long periods to implement effectively. However Easterly, Levine and Roodman (2003) have argued that the Burnside

and Dollar results are sensitive to the definitions of the variables, extended data, and alternative specifications, concluding that their criticisms reduce confidence in Burnside and Dollar's finding that aid promotes growth in countries with sound policies. However, Easterly et al. did not rule out that aid may have some positive impact on the growth rate.

A weakness in the Burnside and Dollar approach is that it is not obvious on which type of growth model their specification of the growth-aid relationships is based (also pointed out by Easterly, Levine and Roodman). We also have reservations about the consistency between the specification used in Burnside and Dollar and much of the



empirical work that followed the Burnside and Dollar methodology. Irrespective of which growth theory is used (exogenous or endogenous) to derive a specification, such as in Burnside and Dollar, it seems that what can be estimated with annual time series data or three to four year growth rates in the panel data models is only a production function. Unless growth rates measured over 30 years or more are used, as in the cross-section studies, the dependent variable (the growth of output) is unlikely to be representative of the steady state growth rate. If this interpretation is accepted, at best only a production function can be estimated with such short periods of data. Therefore, the growth equations cannot be steady-state growth equations. Specifications that fail to recognise this are unreliable. They have serious misspecification biases because they ignore the role of factor inputs in the specifications (see Rao 2007a for further discussion). The main objective of this analysis is to show the usefulness of one such simple modification and extension to estimate properly the steady-state growth effects of aid.

### **Empirical research on Pacific island countries**

Empirical works on the growth effects of aid in Pacific island countries have used different approaches and techniques. This is welcome, because if different models and methods give similar conclusions, confidence in their conclusions will be higher. However, at the outset it should be pointed out that the statistical techniques and specifications used in these papers are less than satisfactory and their conclusions differ. Confusion in these works—and in several other similar studies—is due to a lack of realisation that with country-specific time series data it is possible only to estimate

a production function or its augmented variants. Many investigators mistakenly assume that they are estimating a growth equation. This is so because the dependent variable is transformed into the rate of growth of output due to unit roots in the variables. In virtually all empirical works of this nature it is not known whether the specifications are based on the exogenous Solow (1956) model or the endogenous growth models of Romer (1986) and others. No matter which model is used, it is possible only to estimate a production function or its augmented version with annual data, because the annual frequencies are too short for estimation of steady-state growth equations.

It is possible to derive the steady-state growth rate implied by the exogenous models with the estimated parameters of the augmented production function (see Rao 2007b, where estimates of the steady-state growth rates have been derived for selected Asian countries). In the Solow-type exogenous growth models the steady-state growth rate is directly estimated as the coefficient of the trend in the production function. However, it is possible to modify the Solow model by assuming that total factor productivity (TFP) also depends on other variables, such as aid. But the scope for such modifications is limited because the individual effects of several such growth factors cannot be accurately estimated due to multi-collinearity between them and because they are usually trended.<sup>1</sup>

### **Feeny (2005)**

Feeny (2005) comprehensively examined the growth effects of development aid in Papua New Guinea using the bounds test approach. Although there is some awareness that he is actually estimating an augmented production function, Feeny did not include in the specification the two basic factor inputs, capital and labour. Feeny used the investment ratio as a proxy





for capital and a time trend as a proxy for employment. Neither is satisfactory: the investment ratio is not a good proxy for capital and a deterministic trend is mainly used to capture the rate of technical progress (TFP), not employment, in the estimation of production functions (see Rao, Singh and Gounder, 2007, for a discussion of problems caused by using the investment ratio as a proxy for capital). Contrary to his assertion that the dependent variable is the rate of growth of output, the specification of the long-run equation in the levels of the variables in Feeny (2005:Table 2) takes the following general form

$$\ln Y = \alpha_0 + \alpha_1 \ln INV + \alpha_2 \ln TRADE \\ + \alpha_3 GOV + \alpha_4 SAP + \alpha_5 T \\ + \alpha_6 \ln AID + \alpha_7 CRISIS \quad (1)$$

where  $Y$  is GDP and  $INV$  is the ratio of investment to GDP (a proxy for capital),  $TRADE$  is the ratio of exports plus imports to GDP,  $GOV$  is an index of the quality of governance, and  $SAP$  takes the value 1 during periods when PNG made World Bank's structural adjustments,  $T$  is trend—a combined proxy for labour and TFP— $AID$  is the ratio of aid to GDP, and  $CRISIS$  is a dummy variable to capture the impact of shocks not captured by the other explanatory variables.

Feeny finds that only the project aid component of total aid had any significant (at the 10 per cent level) positive effects on the growth rate. The elasticity of output with respect to project aid is high at about 1.3. Many of his other variables, especially total aid and the proxy for capital, were found to be insignificant. The coefficient of the investment ratio is negative in all equations; indicating that it is not a good proxy for the missing capital variable. Therefore, Feeny's conclusion that project aid had a significant effect on the level of output is not reliable. Thus it is necessary to re-examine the

validity of this conclusion with a properly specified production function and its augmented versions.

### Jayaraman and Choong (2006)

Jayaraman and Choong (2006) have a good survey of the growth and aid literature but their application of the controversial Burnside and Dollar (2000) panel data model to time series data for Fiji is unsatisfactory. As in Burnside and Dollar, interactive aid and policy variables have been used. The good policies variable is proxied by the ratio of recurrent government expenditure to total government expenditure. One would expect a negative coefficient for this variable. Their estimated cointegrating equation, with an additional non-linear aid variable for the period 1970 to 2002 for Fiji, is

$$\ln y = 33.95 \ln AID - 3.94 \ln AID^2 \\ - 125 \ln RATIO \\ + 69.09 \ln(AID \times RATIO) \\ - 0.46 \ln RFX \quad (2)$$

where  $y$  is per capita GDP,  $AID$  is per capita aid,  $RATIO$  is the ratio of recurrent government expenditure to total government expenditure, and  $RFX$  is the real exchange rate.

Note that this specification, as in Feeny (2005), does not include capital and labour. The authors do not show much awareness that, with annual data, they can only estimate an augmented production function. This misspecified equation gives some implausible results. First, contrary to expectations, the coefficient of the  $AID$  and  $RATIO$  interactive term is positive. One would expect that higher recurrent government expenditure would have a negative effect on output and growth. Second, the correct derivation of the elasticity of output with respect to aid should have been



$$\frac{\partial \ln y}{\partial \ln AID} = 33.95 - 7.88 \ln AID + 69.09 \text{RATIO} \quad (3)$$

Jayaraman and Choong ignore the *RATIO* term in their derivation of Equation 3. When correctly derived with the last term included, Equation 3 implies that the elasticity of per capita income with respect to per capita aid is 299.9; meaning that a one per cent increase in per capita aid will increase per capita incomes by about 300 per cent.<sup>2</sup> This is not a credible finding. Furthermore, the elasticity increases with *RATIO*, which is somewhat implausible.

### Pavlov and Sugden (2006)

In estimating growth equations for the Pacific island countries, Pavlov and Sugden (2006) use a specification that is essentially based on the Burnside and Dollar (2000) equations and panel data methodology. Pavlov and Sugden differ from Feeny and Jayaraman and Choong in that they used a simple panel data approach.<sup>3</sup> Pavlov and Sugden's data includes seven Pacific island countries with three year rates of growth covering the period 1982 to 2004. Since one period lagged values of the explanatory variables were used, there are 49 observations.<sup>4</sup>

Using the Ordinary Least Squares (OLS) regression technique, Pavlov and Sugden estimated two regressions in which the rate of growth of output (over three years) is the dependent variable. The explanatory variables are: the real effective exchange rate (REER); a multiplicative term of the fixed exchange rate and the real exchange rate (FixedFX×REER); domestic budget financing, which is proxied with the ratio of the budget deficit to GDP; lending to the private sector measured as the ratio of credit to the private sector to GDP; the export ratio; the World Bank's Country Policy and Institutional Assessment (CPIA) index; an ethnic diversity index; a governance index; the ratio of the overseas population to the

domestic population; an index of political freedom; the initial level of GDP; the ratio of aid to GDP (ODA); and the square of ODA. They also estimated separate regressions to measure the impact of aid from Australia. Their selection of the explanatory variables was justified by citing references to many empirical works stimulated by Burnside and Dollar. However, this is inadequate.

Pavlov and Sugden also estimated parsimonious versions of their initial regressions (with 11 explanatory variables) by deleting insignificant and correlated variables. We use these parsimonious equations to summarise their main findings.

In their compact equations with eight explanatory variables, only four variables were significant—World Bank's CPIA, lending to the private sector, aid, and its square. Although it would have been desirable to estimate another shorter equation with only these four significant variables, their main conclusion is that aid has a significant and positive effect on growth but that this effect starts to decline when the aid ratio reaches about 50 per cent of GDP and becomes zero at 100 per cent. The only country close to this maximum effect of aid is Kiribati where the average aid ratio is about 48 per cent. Therefore, it may be said that at current levels aid has a positive growth effect in all seven Pacific island countries.

Their estimated marginal effect of aid implies that when the aid ratio increases by one per cent, the growth rate increases by 0.42 per cent. Pavlov and Sugden also found that Australian aid has a higher growth effect. A one per cent increase in aid from Australia contributes 1.2 per cent to the growth rate. Although these findings appear to be reasonable and pleasing to the donors, further work is necessary because of the weaknesses in the Burnside and Dollar type specifications.<sup>5</sup>





### Brindly (2004)

The approach of Brindly (2004) is closer in spirit to Burnside and Dollar (2000). However, as he points out in the abstract, 'while there is statistical support for the hypothesis that aid works in a good policy / institutional environment, its economic significance is marginal. [He] then goes on to show that aid has not been as effective in the Pacific island countries as compared to the rest of the developing world, even when taking account of factors such as institutional quality, initial income, and country size'. In this respect Brindly differs from the other works that found significant effects for aid and is in agreement with the observations of Hughes (2003) on the ineffectiveness of aid in the Pacific and the findings of Rao and Takuria (2008) for Kiribati.

Ignoring the relevant subscripts for cross section specifications, a simplified version of the basic relationship specific by Brindly is

$$\Delta \ln G = f(y, a, p, z, g) \quad (4)$$

where  $\Delta \ln G$  is growth in real per capita GNI,  $y$  is the natural logarithm of initial GNI,  $a$  is the ratio of aid to GNI,  $p$  reflects the quality of institutions,  $z$  is a vector of other variables that may plausibly affect growth rates, and  $g$  is a fixed time effect. Brindly noted that aid flows may be endogenous and for this reason Two Stage Least Squares (2SLS) estimates were examined. He also introduced three multiplicative terms to test if the effects of aid depend on fulfilling the conditionality conditions of the IMF and World Bank. These conditionality effects were tested with multiplicative terms of aid and institutions, policy, and a region-specific dummy 'Pacific'.

His data for 109 countries were nine four-year period averages from 1966–69 to 1998–2001, giving 658 observations (instead of the full 981 due to the non-availability of

data for some countries for all nine panels). The Pacific island countries included are Fiji, Federated States of Micronesia (FSM), Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu. However, due to paucity of data the number of observations included for these Pacific island countries were as follows: FSM (four observations), Fiji (eight observations), Kiribati (four observations), Marshall Islands (one observation), Papua New Guinea (seven observations), Samoa (four observations), Solomon Islands (five observations), Tonga (four observations), and Vanuatu (four observations).

The main results from OLS estimates are reported in his Table 3. Estimates with Generalised Least Squares (GLS) and 2SLS are only briefly discussed. The effect of aid on growth in the baseline equation in Table 3, without the multiplicative variables, was found to be negative and insignificant. In Brindly's preferred equation (3.4) the coefficients of Aid, Aid×Institutions and Aid×Pacific (dummy variable) were all significant. The estimates of their coefficients, respectively, are: 5.92, 8.34 and –6.55. However, the institutions variable was negative, except for Samoa, and ranged from –0.748 for Solomon Islands to 0.48 for Samoa. Therefore, the overall effect of aid is almost insignificant for many Pacific island countries. GLS estimates of this equation implied even lower effects of aid on growth. 2SLS estimates of the equations were not robust and were sensitive to the choice of instrumental variables. These are not reported.

Brindly introduced vulnerability variables (remoteness, natural disasters, limited access to external capital, limited size, and so on) into the specification. Results in his Table 5 use three vulnerability measures, viz., a composite vulnerability index (CVI), an economic vulnerability index (EVI) and a general vulnerability index (VI).



Both OLS and GLS estimates are reported. In all six equations in Table 5 the coefficients of Aid, Aid×Institutions, Aid×Pacific and the vulnerability indices were all significant except in equation 5.1 where CVI was insignificant and in equation 5.3 where the coefficient of Aid was insignificant. However, in none of the equations was the coefficient of Aid large enough to offset the negative effects of Aid×Institutions and Aid×Pacific. Therefore, it may be concluded that the effect of Aid on the growth rate of Pacific island countries is negligibly small or even negative.

Brindly's conclusions are noteworthy because they have implications for further work on the growth-aid relationship for Pacific island countries. His two main conclusions are

[w]e are, unfortunately, left with an unsatisfying gap in our argument; while the Pacific does appear to have received substantially more aid, and generated less economic growth from it than the rest of the developing world, this paper has been unable to isolate the reasons for this. On the basis of the empirical estimates presented it does not seem to be the result of low institutional quality, as our model does at least take some account of this. Nor does it appear to be due to the relatively small population size of most of the Pacific island countries, as this effect is separately accounted for in our model. And finally, published measures of vulnerability—economic and environmental—also appear to be unable to explain the differences (Brindly 2004:26).

As Roodman [2003] notes, the idea that aid works in a good policy environment is an appealing one, with its combination of realism and optimism. However, while this study

supports this conclusion in terms of statistical significance, it finds that the effect of aid on growth is small compared to the size of the aid flows required to generate this growth.

...the effect of an equivalent increase in aid for a PIC is less than that for other developing countries, even taking account of factors such as the quality of institutions and country size issues (Brindly 2004:27–8).

Brindly's work is noteworthy for the quality of analysis and techniques employed. Although his work and the earlier works have, by and large, followed the seminal approach of Burnside and Dollar (2000), in our view the main weakness in all these approaches is the specification of the growth equation. Since either annual data or averages over three to four years have been used, the rate of growth estimated is not the steady-state growth rate. Since none of these specifications include factor inputs, the extent to which misspecification biases have affected parameter estimates is not known. While Pavlov and Sugden and Brindly used panel data they ignored the standard panel data econometric techniques. While the econometric techniques used by Feeny and Jayaraman and Chung for their time series data are appropriate, the major weakness in these works is the aforesaid specification weaknesses.

### Gounder (2001)

Gounder (2001) estimated an aid-growth relationship for Fiji using various types of aid, grant aid, loans, and technical cooperation aid, for the period 1968 to 1996. She found that total aid and its components have significant impacts on growth in Fiji. Although she used the Solow (1956) model and showed some awareness that the estimated equation is a production function, following Khan and Reinhart (1990) she





added a number of other variables in an ad hoc manner, and, like many others, simply treated them as shift variables. Furthermore, in spite of an elaborate attempt there is confusion about her ARDL specification and derivation of the long-run determinants of growth. It is well known that in the Solow model the only long-run determinant of the rate of growth of per worker income is the growth rate of technical progress, which is given by the coefficient of time in the production function. It is also not clear how the error correction term (ECM) is specified, estimated, and tested, because no details are given. Gounder's results showed that total aid and its various components have a significant impact on the growth rate in Fiji. However, due to the technical and specification weaknesses, it is difficult to accept these findings.

### Rao and Takirua (2008)

Rao and Takirua (2008) found that aid has a negative effect on the growth rate of Kiribati. As in Gounder (2001), the effects of aid on growth are captured by adding aid as a shift variable into the production function. The estimated equation, with the GETS and NL2S-IV method, is as follows

$$\begin{aligned} \Delta \ln y = & 2.93 - 0.04T \\ & (1.28) \quad (-4.31)^* \\ & - 0.73(\ln y_{t-1}) + 0.65 \ln k_{t-1} \\ & (5.56)^* \quad (1.96)^* \\ & - 0.07 \ln AID_{t-1} + 0.44 \Delta \ln y_{t-1} \\ & (-2.46)^* \quad (3.36)^* \\ & - 3.69 \Delta \ln k_{t-2} - 0.338 Dum90 - 0.31 \Delta \ln AID \\ & (-4.49)^* \quad (-3.53)^* \quad (-1.81)^{**} \end{aligned} \quad (5)$$

$$\overline{GR}^2 = 0.455; SER = 0.150; \text{Sargan's } \chi^2(4) = 2.716[.606]$$

where  $y$  is per worker GDP,  $T$  is time,  $k$  is per worker capital,  $Aid$  is the ratio of aid to GDP, and  $Dum\ 90$  is a dummy variable

for a break in the intercept due to breaks in the trends of many variables.  $\overline{GR}$  is the Pesaran and Smith adjusted measure of the correlation coefficient and the Sargan test is for the choice of instruments.

The main merit of this specification is that there is explicit awareness that what is estimated is actually a production function. The results show that technical progress in Kiribati has been negative and aid simply reduced the efficiency of production. Furthermore, aid has also had a negative effect on the short-run growth of output. Rao and Takirua argue that aid seems to have created a dependence culture and aid money is mostly spent on consumption goods, which consequently created little capacity in the economy. A weakness in this approach is that aid has been added to the production function as a shift variable. Therefore, the effects of aid on the growth rate of output are not captured. In other words only the level effects of aid are estimated.

### Hansen and Headey (2007)

Hansen and Headey (2007) takes a different approach. They are interested in estimating the short-run macroeconomic effects instead of the long-run growth effects in the papers surveyed above. They used the VAR approach for this purpose and examined how aid affects the external (imports) and domestic components of demand of 22 small developing countries. These effects are also known as the absorption (net imports) and expenditure effects (government budget deficit net of aid).

Hansen and Headey discuss various macroeconomic effects of aid through absorption and expenditure effects. One such effect of interest is the impact of aid on investment and productivity, boosting skills through improvements in education and health. The equation used for estimation is the standard equilibrium condition in short-



run macroeconomic models. For simplicity, we suppress the cross-section country and time subscripts. With this simplification the equilibrium condition is

$$Y = C + I + X - M + R \quad (6)$$

where  $Y$  is GDP,  $C$  is total consumption (the sum of household and government consumption),  $I$  is gross fixed capital formation,  $X$  is exports of goods and services,  $M$  is imports of goods and services, and  $R$  is inventory investment. The above equation can be expressed in growth rates as follows

$$\begin{aligned} y &= c + i + x - m + r \\ &= d + x - m + r \end{aligned} \quad (7)$$

$$\text{where } d = c + i \text{ and } y = \frac{\Delta Y}{Y}, c = \frac{\Delta C}{Y} \dots \text{etc}$$

Similarly aid flow is measured as  $a = \Delta \text{aid}/Y$ .

Hansen and Headey selected five variables for the VAR model, output ( $y$ ), aid ( $a$ ), expenditure ( $d$ ), exports ( $x$ ), and a measure of natural disasters ( $W$ ). Inventory investment is ignored because for many countries it was near zero and imports are dropped because it can be ignored due to the income identity; see Equation 6 in Hansen and Headey. Their three main findings are

- aid flows are highly volatile and unpredictable. Therefore, there is a need for aid smoothing in the aid-dependent countries.
- although the sample of countries is relatively homogenous, there is evidence that they have reacted diversely to changes in aid flows.
- in the highly aid-dependent countries most aid is both absorbed and spent. However, they appear to spend more than they absorb, which may lead to short-run macroeconomic imbalances.

It is not known from this work what proportion of spending consists of an

increase in investment and an increase in consumption. If these components were estimated it might have been possible to say how aid affects investment and the growth rate in an indirect way only in the transition period of the economy from one to another steady state.

## Further empirical results

Our survey of earlier work on Pacific island countries has revealed that many empirical studies of the effects of aid on growth have both specification and estimation weaknesses. Therefore, in this section we present results based on what we believe to be a more satisfactory specification for estimation with country-specific annual time series data. Panel data estimation with these data is outside the scope of this paper. We first present a few results for Fiji based on our approach. We then present some results for Solomon Islands and Papua New Guinea.

The specification of our production function is the standard Cobb-Douglas production function with constant returns and Hicks-neutral technical progress (in per worker units), as follows

$$y_t = A_0 e^{gt} k_t^\alpha \quad (8)$$

where  $y$  is output per worker,  $A_0$  is the initial stock of knowledge, assumed to grow at the rate of  $g$  per period, and  $k$  is capital per worker. Since the variables have unit roots,<sup>6</sup> our estimate of this basic output equation for Fiji with the GETS formulation and the two-stage, non-linear instrumental variables method (2SNLLS-IV) is as follows.<sup>7</sup>

$$\begin{aligned} \Delta \ln y_t &= -1.31(\ln y_{t-1} - 2.365 + 0.005T + 0.225 \ln k_{t-1}) \\ &\quad (7.85) \quad (42.75) \quad (13.68) \quad (8.93) \\ &\quad 0.375 \Delta \ln k_t - 0.024 COUP + 0.042 DUM95 \\ &\quad (3.93) \quad (2.25) \quad (3.82) \end{aligned} \quad (9)$$

$$R^2 = 0.752; \text{ Sargan's } \chi^2 = 2.257[.813] \quad \chi^2_{\text{non}} = 0.821[0.37];$$

$$\chi^2_{\text{spec}} = 0.033[0.86]; \chi^2_{\text{line}} = 0.725[0.696]; \chi^2_{\text{int}} = 0.594[0.441]$$





$T$  is a time trend,  $COUP$  is a dummy for the political coups, and  $DUM95$  is a dummy to capture investment and export incentives in 1995.  $T$ -ratios are in the parentheses below the coefficients. The  $\chi^2$  test statistics, with  $p$ -values in the square brackets, are for serial correlation, functional form misspecification, non-normality in the distribution of residuals and heteroscedasticity. The insignificant Sargan test indicates that our choice of instruments is valid.

The above equation is well determined and the Ericsson-MacKinnon (2002) cointegration test statistic indicates cointegration at the 5 per cent level. The estimated share of profits at 0.22 is plausible but less than its stylised value of 0.3. The coefficient of trend at 0.005 indicates that TFP in Fiji is low, confirming the many growth accounting exercises at the University of the South Pacific for Pacific island countries. Equation 9 is our baseline equation for comparisons.

We report below estimates of an ad hoc specification (frequently used by many), without capital and labour, to capture the effects of aid.

$$\Delta \ln y_t = -0.770(\ln y_{t-1} - 3.356 + 0.003T + 0.06526 \ln aid_{t-1}) \quad (4.86) \quad (16.44) \quad (2.27) \quad (2.99)$$

$$0.108 \Delta \ln aid_t + 0.021 DUM95 \quad (4.19) \quad (1.99) \quad (10)$$

$$R^2 = 0.306; \text{Sargan's } \chi^2 = 6.8895[.441] \quad \chi^2_{sc} = 0.365[0.546];$$

$$\chi^2_{nc} = 0.000[0.99]; \chi^2_n = 1.133[0.568]; \chi^2_b = 0.085[0.771]$$

As our baseline equation, this equation is also well determined. However, the Ericsson-MacKinnon test implies that there is no cointegration. Subject to this caveat, the above results show that aid has a significant, permanent, level effect and a short-run growth effect. A 10 per cent increase in aid temporarily increases growth rate by one per cent and the level of output permanently by 0.6 per cent. These results

seem more plausible than the findings of Jayaraman and Choong (2006). However, compared to our baseline equation, the overall explanatory power of this equation is poor because its adjusted  $R^2$  of 0.306 is less than half of the 0.752 in the baseline equation.<sup>8</sup>

Since it is hard to imagine a production function without capital and labour, we estimated a production function augmented with the aid variable. There are two ways of introducing aid into the production function. First, it may be assumed that aid impinges on the infrastructure of the economy as in the endogenous growth models (see Feeny 2005 for an explanation). Second, it is difficult to extend the Solow (1956) exogenous growth model for aid to have permanent level effects like human capital development as in Mankiw, Romer and Weil (1992). This approach is possible only if it can be justified that aid has an impact on the productivity of labour and/or capital.

We use a new approach whereby in the Solow model aid is assumed to have a permanent, albeit a very small, growth effect. Our approach is purely empirical in spirit to capture the permanent growth effects of any growth-improving variable(s) that have been rationalised by the endogenous growth models.

In the Solow (1956) model the steady-state growth rate is given by  $g$  in equation (8), which, in turn, is assumed to depend only on time. In other words, the unknown determinants of  $TFP$  in the production function are assumed to be highly trended. Therefore, the Solow residual may also be our measure of ignorance of the determinants of growth. We assume that  $TFP$  depends on some variables, in addition to time, that have been identified to have permanent growth effects, for example, aid, openness of the economy, and human capital. Therefore, if aid has a permanent growth effect, the earlier Cobb-Douglas production function



in Equation 7 can be modified by expressing  $g = (g_1 + g_2 \text{aid})t$  and the production function may be written as

$$y_t = A_0 e^{(g_1 + g_2 \text{aid})t} k_t^\alpha \quad (11)$$

Note that if aid has no permanent growth effect,  $g_2$  will be insignificant and  $TFP$  depends only on the time trend. Other forms are also possible, for example,  $g = (g_1 + g_2 \text{aid}^{-1})t$  ( $g_1 t + g_2 \text{aid}$ ) etc. In the latter formulation the evolution of the stock of knowledge is assumed to be  $A_t = A_0 (e^{g_1 t} e^{g_2 \text{aid}_t})$ .

This formulation was used by Bloom, Canning and Sevilla (2004) to capture the effects of health on growth. A disadvantage with this formulation is that it is difficult to say that aid or health has a permanent growth effect because by growth we mean a certain rate of increase in output per period. The advantage of the inverse form (given above) is that the growth effects of aid and similar variables will eventually taper off. Such a non-linear specification is useful to offer support with the exogenous models to Jones' (1995) criticisms that there is no evidence from time series data that growth has increased proportionately with the observed persistent increases in growth factors like R&D and investment expenditures.

The estimate of Equation 11 with the GETS formulation and the NLLS-IV method for Fiji is as follows

$$\begin{aligned} \Delta \ln y_t = & -1.381(\ln y_{t-1} - 3.273 + (0.007 + 0.000 \ln \text{aid}_{t-1})T) \\ & (0.09) \quad (44.44) \quad (1.02) \quad (0.17) \\ & + 0.223 \ln k_{t-1} - 0.400 \Delta \ln k_t \\ & (9.78) \quad (3.28) \\ & - 0.022 COUP + 0.045 DUM95 \\ & (3.33) \quad (3.43) \end{aligned} \quad (12)$$

$$\begin{aligned} R^2 &= 0.739; \text{Sargan's } \chi^2 = 5.307[0.505]; \chi_w^2 = 0.270[0.604]; \\ \chi_a^2 &= 0.26[0.871]; \chi_c^2 = 0.621[0.733]; \chi_b^2 = 0.768[0.381] \end{aligned}$$

This equation is well determined and its summary statistics are comparable to the baseline equation. The Ericsson-MacKinnon

test implies cointegration.<sup>9</sup> Note that the permanent growth effect of aid is almost zero and insignificant, which is not an unexpected result. We also estimated a non-linear specification for the effects of aid where the reciprocal of aid was used, but the coefficient of aid was again near zero and insignificant. Finally, we estimated a modified baseline equation so that aid has only a temporary growth effect. Neither the current nor the lagged values of the change in the log of aid were significant. Therefore, we may say that total aid does not seem to have any significant effects on the level or growth of output in Fiji. However, it is possible that some components of aid, for example project aid (as in Feeny 2005 for Papua New Guinea), may have a significant effect. We plan to investigate such effects of aid in later work. The main conclusion from this exercise is that the effects of aid (or any other growth and/or output enhancing variable) are likely to be biased if such equations are estimated with misspecified equations and without including capital and labour in the production function.

Given below are some results on the effects of aid in the Solomon Islands. These results are consistent with our findings for Fiji. The comparable equations—the baseline equation, an ad hoc growth-aid equation, and an equation with the augmented production function—have been estimated. The estimated baseline equation is

$$\begin{aligned} \Delta \ln y_t = & -0.464(\ln y_{t-1} - 3.030 + 0.018T + 0.290 \ln k_{t-1}) \\ & (7.71) \quad (5.32) \quad (2.57) \quad (1.88)^* \\ & 0.640 \Delta \ln k_t - 0.140 DUM98 \\ & (7.87) \quad (3.68) \end{aligned} \quad (13)$$

$$\begin{aligned} R^2 &= 0.875; \text{Sargan's } \chi^2 = 5.307[0.505]; \chi_w^2 = 4.82[0.03]; \\ \chi_a^2 &= 0.266[0.61]; \chi_c^2 = 0.174[0.92]; \chi_b^2 = 0.930[0.34] \end{aligned}$$

An asterisk indicates significance at the 10 per cent level. The GETS formulation of the arbitrary aid equation did not produce any meaningful results. However, the





Johansen maximum likelihood method gave the following cointegrating and short-run dynamic ARDL equations, respectively.<sup>10</sup>

$$\ln y = 1.481 \ln aid - 0.112 \ln aid^2 \quad (14)$$

$$\begin{aligned} \Delta \ln y_t = & -9.1883 + 0.008T - 0.575ECM_{t-1} \\ & (5.30) \quad (2.94) \quad (5.32) \\ & 0.095\Delta \ln y_{t-1} - 1.316\Delta \ln aid_{t-1} \\ & (0.55) \quad (3.01) \\ & + 0.099\Delta \ln aid_{t-1}^2 \\ & (2.90) \end{aligned} \quad (15)$$

$$\begin{aligned} \bar{R}^2 &= 0.519; \chi^2_{sc} = 0.136[0.712]; \chi^2_{it} = 0.297[0.59]; \\ \chi^2_n &= 6.516[0.04]; \chi^2_s = 0.085[0.77] \end{aligned}$$

The above equation gives the plausible result that aid has a positive and non-linear declining effect on output. The plot of output (log of output per worker on the vertical axis) and aid (log of aid per worker on the horizontal axis) shown in Figure 1 implies that aid reaches its maximum effect when log (aid) is 6.62. The mean value of log (aid) per worker is 6.26, implying that in the Solomon Islands aid is near its maximum positive effect.

When we estimated the aid equation with per worker capital with the Johansen method, the coefficient of capital was negative. Therefore, we have estimated this equation with the GETS specification and obtained the following.

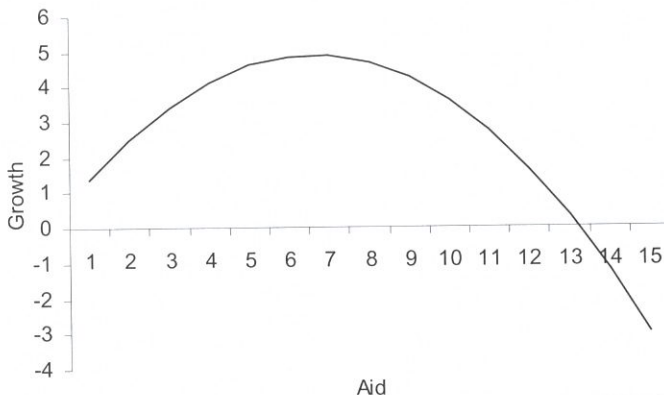
$$\begin{aligned} \Delta \ln y_t = & -0.509(\ln y_{t-1} - 3.255 + (0.025 - 0.001 \ln aid_{t-1})T \\ & (7.71) \quad (6.35) \quad (3.48) \quad (0.55) \\ & + 0.236 \ln k_{t-1} + 0.598 \Delta \ln k_t - 0.167 DUM98 \\ & (1.72)^* \quad (3.90) \quad (6.97) \\ & - 0.119 DUM81 + 0.008 \Delta \ln aid_{t-1} \\ & (3.32) \quad (0.29) \end{aligned} \quad (16)$$

$$\begin{aligned} \bar{R}^2 &= 0.862; \text{Sargan's } \chi^2 = 2.853[.583]; \chi^2_{sc} = 3.65[0.06]; \\ \chi^2_{it} &= 0.098[0.76]; \chi^2_s = 0.377[0.83]; \chi^2_n = 0.719[0.40] \end{aligned}$$

Although the summary statistics of this equation are satisfactory, the coefficient of aid is negative and insignificant. It was necessary to include an additional dummy variable DUM81 and an insignificant lagged change in aid to make the coefficient of capital significant.<sup>11</sup> Estimates with a non-linear aid variable did not produce any sensible result.

We have a limited amount of data on aid for Papua New Guinea and the estimates of the baseline production function did not produce plausible results for the period

Figure 1 The aid-growth relationship



Aid



1978 to 1999. Therefore, we constrained the coefficient of capital to 0.3, which is the stylised value in many growth accounting exercises, and estimated an augmented aid equation to arrive at

$$\begin{aligned} \Delta \ln y_t = & -0.356(\ln y_{t-1} - 8.896 + (0.087 - 0.032 \ln aid_{t-1})T \\ & (2.19) \quad (180.38) \quad (6.71) \quad (5.62) \\ & + 0.30 \ln k_{t-1}) \quad 0.304 \Delta \ln k_t - 0.212 \Delta \ln aid_{t-1} \\ & (constrained) \quad (2.34) \quad (1.60) \\ & - 0.071 CRISIS \\ & (6.02) \end{aligned} \quad (17)$$

$$\begin{aligned} R^2 &= 0.395; \text{Sargan's } \chi^2 = 3.191[.671]; \chi^2_{sc} = 1.134[0.287]; \\ \chi^2_{\eta} &= 6.253[0.012]; \chi^2_{\epsilon} = 1.142[0.565]; \chi^2_{\delta} = 0.688[0.41] \end{aligned}$$

where *CRISIS* is a dummy variable, as in Feeny (2005), taking values of unity in 1989, 1994 and 1997. Although the summary statistics of this equation are not comparable to our estimates for Fiji and Solomon Islands, the effects of aid (as a ratio to GDP) on growth are negative in the short and long run. *Ad hoc* specifications with the aid variable alone did not yield any meaningful results.

These results, although selective, indicate that when country-specific time series estimates are based on misspecified equations, they are unreliable. Our results for Fiji, Solomon Islands and Papua New Guinea should be seen as examples of the consequences of such misspecifications. As in Feeny (2005), this also calls for disaggregation of aid into, at least, project and non-project components. Much attention is given to the effects of aid on growth with a view to deriving general guidelines for aid allocation. The currently dominant view is that aid is more effective in countries with good economic policies and institutions. But this is difficult to accept in the light of our results. In our view it is more useful to investigate how aid can be made more effective in a country or region than developing some questionable aid effectiveness rule as if it is a universal law.

## Conclusions and limitations

This article reviewed the literature on the aid-growth relationship with respect to the Pacific island countries. This review showed that all the empirical work on the Pacific island countries has closely followed the specification and methodology of Burnside and Dollar (2000). It is pointed out that there are serious misspecification errors in all this earlier work. Consequently, there are significant differences between the conclusions of some papers that aid is effective in improving growth rates and others that find that the growth effects of aid are insignificant in the Pacific island countries. The latter view is supported by our results based on a modified production function that has been extended to capture the effects of aid on the steady-state growth rate of output in Fiji, Papua New Guinea and Solomon Islands. Our empirical work also supports controversial observations by Hughes (2003) that aid has often been misused in the Pacific island countries.

These conclusions are subject to several caveats. First, we have provided results for only the three larger countries. Second, we did not allow the conditionality variables to play any role. Third, we have ignored all other possible growth-enhancing variables such as learning by doing, education, and health. However, inclusion of these variables is most likely to reduce the growth effects of aid. Finally, given that our country-specific samples are small, it would have been better to estimate the relationships with the appropriate panel data methods where the variables are non-stationary. For these reasons this paper should be seen mainly as a methodological comment on the specification of the aid-growth relationship. It is hoped that other scholars will follow some of our guidelines to the gaps in the existing literature.





## Notes

- <sup>1</sup> Hoover and Perez (2004) have pointed out that there are more than 80 potential growth determinants to select for estimating cross section regressions, although the theoretical underpinnings for selecting a set of growth determinants are not always clear. Similarly, Easterly, Levine and Roodman (2003), commenting on the quality of specifications in the cross section studies, have observed that: 'This literature has the usual limitations of choosing a specification without clear guidance from theory, which often means there are more plausible specifications than there are data points in the sample'.
- <sup>2</sup> In 2002, the value for *AID* was \$62.62 and for *RATIO* was 75.26 per cent. These values are used in our calculation of this elasticity.
- <sup>3</sup> See Murthy (2007) for an excellent exposition of panel data methods.
- <sup>4</sup> Since the rates of growth of the variables were used for each country there are eight panels of three-year averages (for example, growth rate during 1982–84, and so on) for the period 1982–2004. However, since the lagged values for some explanatory variables are used, for seven countries there are 49 panels. The seven countries in the study are Cook Islands, Fiji, Kiribati, Samoa, Solomon Islands, Tonga and Vanuatu.
- <sup>5</sup> Furthermore, as Easterly, Levine and Roodman (2004) have noted, the original Burnside and Dollar specifications are highly sensitive to alternative definitions of the variables and the inclusion and exclusion of other explanatory variables.
- <sup>6</sup> We have used the ADF and Generalised ADF tests and found that all the variables in our regressions have unit roots. To conserve space these results are not reported.
- <sup>7</sup> Lagged values of the variables are used as instruments. The Sargan Chi-square test was insignificant at the 5 per cent level, indicating that our choice of instruments is appropriate.
- <sup>8</sup> Addition of the square of aid or the Burnside-Dollar (2000) type of aid-policy interactive term did not improve the results.
- <sup>9</sup> There is generally a misperception that the estimate of the adjustment coefficient

should be less than unity, that is,  $|\lambda| < 1$ . When  $\lambda$  is less than unity, convergence would be smooth; when it is more than unity, convergence would have cycles. When there is an ECM adjustment mechanism with a negative coefficient, there would always be convergence.

- <sup>10</sup> A second-degree VAR is used and the computed Eigen value test statistic (with 5 per cent critical values in brackets) for the null of no cointegration is 25.52 (24.35) and for the null that there is at most one cointegration vector is 12.37 (18.33). The cointegration vector for output is also tested. The lagged ECM, normalised on output, is insignificant in the aid equation. The estimated coefficient has the wrong sign of 1.259 with a p-value of 0.15. It is pointless to test that this equation is for the square of aid.

- <sup>11</sup> The DUM81 variable was added because when we tested for cointegration with structural breaks, in all the four types of models the break point was found to be 1981. However, it should be noted that the Gregory and Hansen method is appropriate for the Engle-Granger two-step method and not for GETS. Furthermore, the Ericsson-MacKinnon test indicates that there is no cointegration in the above equation. Addition of a non-linear aid term gave similar weak results.

## Data appendix

$y$  is output per worker obtained as a ratio of GDP (1990 prices) to the labour force. Data on GDP was obtained from the United Nations database (2006) and the Asian Development Bank database (2006). Labour force data was obtained from the World Bank's World Development Indicators (2003) and interpolated (from 2000 to 2005) using the proportion of working age population (15–64) to total population.

$k$  is capital per worker computed as the ratio of the real stock of capital to the labour force. Capital stock was estimated using the perpetual inventory method with a 4 per cent rate of depreciation.



*Aid* is the ratio of total aid to GDP. Data was obtained from World Development Indicators (2005) and from 2000–2005, the aid ratio is estimated using data from the Asian Development Bank website.

*COUP* is a dummy for the political coups in Fiji. It takes a value of unity in 1987 and 2000 but zero otherwise.

*DUM81* represents the break point in data as suggested by Gregory and Hansen's (1996) tests for structural breaks. It takes a value of unity from 1981 to 2005 and zero otherwise.

*DUM95* captures investment and export incentives in Fiji in 1995. It takes a value of unity in 1994–96 and zero in other periods.

*DUM98* captures the effects of devaluation of the Fiji dollar in 1998. It takes a value of unity in 1988–89 and zero in other periods.

*CRISIS* is a dummy variable which takes values of unity in 1989, 1994 and 1997 but zero otherwise.

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