The effects of exports, aid and remittances on output: The case of Kiribati

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Abstract

Country specific time series models of the determinants of output for the small developing island countries in the Pacific region are relatively few. This paper explores the applicability of the framework underlying Solow (1956) to analyze the determinants output in Kiribati for the period 1970-2005. It is found that technical progress in Kiribati has been negative virtually offsetting the positive effects of factor accumulation. Aid and remittances have negative effects and exports have only a small positive effect in the short run.

Keywords: Kiribati, Growth, Aid, Exports and Remittances

1 The authors are respectively Professor of Economics (contact author) and graduate student. Email for the contact author is rao_b@usp.ac.fj. This paper is partly based on the M.A. thesis under progress of the second author.

1. Introduction

The purpose of this paper is to explore the use of the Solow (1956) model and its extended versions. This is a relatively unexplored area for the Pacific Island countries (PICs) except for Fiji by some University of the South Pacific (USP) economists like Rao, Singh and Fozia (2006) and Rao and Rao (2006). In doing so, we analyze the significance of the exports, remittances and aid, besides the two basic conditioning variables viz., capital (K) and labour (L), for the determination of output in Kiribati.[2] Our approach differs from many *ad hoc* applications where the growth rate of output is simply regressed on any variable (e.g., defense expenditure) or a set of variables without incorporating the conditioning variables into the specification. At the least this amounts to gross misspecification and the effects of the selected variables may be overestimated. Such *ad hoc* studies are too many to cite. We shall later use one or two examples to illustrate some weaknesses of such *ad hoc* specifications.

The aforesaid USP methodology of Rao et al which is used in this paper is similar to the Mankiew, Romer and Weil (1992), MRW hereafter, extension to the Solow model in which the basic neoclassical Cobb-Douglas production function is augmenting with shift variables like human capital. MRW found that the Solow residual, which actually is a measure of our ignorance of the determinants of growth rate, could be considerably reduced without the need for changing the basic simplifying assumptions of the Solow model. Acemoglu (2004) considers the work of MRW as an attempt to revive the usefulness of the basic Solow growth model; see also Rao and Singh and Nisha (2006) and Asteriou and Price (2004). Our attempt in this paper with time series data modifies the MRW extension to the Solow model with cross section data.

At the outset, it may be stated that although it is desirable to use a few alternative methods of estimating cointegrating equations, only the general to specific approach (GETS) of Hendry and

2 Kiribati consists of 33 atoll islands with a total land area of 811 square kilometers, lying astride the equator situated in a 3.6 million square kilometers of its Exclusive Economic Zone. Its population in 2005 was about 103,000 and real GDP, in Australian dollars, in 2005 was about 45 millions, implying a per capita income of about A$420. The average growth rate of GDP for the period 1971 to 2005 was almost zero.

the systems based Johansen Maximum Likelihood techniques (JMLVECM) yielded meaningful results for our data. Furthermore, we have used the instrumental variable approach in the single equation GETS approach to minimize any endogenous variable bias. Needless to say these two techniques are second to one. Nevertheless, given the exploratory nature of our attempt, whatever policy implications are derived from our empirical estimates need further investigations. Therefore, our findings should be interpreted cautiously.

This paper is organized as follows. Unit root test results are in Section 2. Section 3 contains the specification and cointegration issues. Various empirical results with the basic and extended Solow model are in Sections 4 and 5 respectively. Section 5 also contains results with *ad hoc* specifications. Section 6 concludes.

2. Unit Roots

The purpose of unit root tests is to test for the stationarity of a time series. Stationary series are said to be integrated of order zero I(0). There are alternative unit root test procedures, each claiming that it has more power against the null of unit root in a variable. Therefore, we shall use some popular alternative tests to test for unit roots in the logs of our variables viz., output per worker $(\ln y)$, capital per worker $(\ln k)$, export ratio which is export divided by output $(\ln EX)$, aid as ratio to output $(\ln AID)$ and remittance ratio which is measured as real remittances divided by employment $(\ln REM)$. In doing so, the following tests are used viz., the augmented Dickey Fuller (ADF), the ADF with generalized least squares (ADFGLS) of Pantula (xxxx) which is more powerful than OLS based ADF, the Phillips-Perron non-parametric test (PP), KPSS and the Elliot-Rothenberg-Stock test (ERS).[3] These tests did not yield uniform results, but it is generally believed that ADFGLS and ERS are more powerful and these two tests indicate that all our variables are unit root variables. To conserve space we only report ADF, ADFGLS and ERS test results in Table 1.

Our unit root test results are as follows. The null hypothesis of unit root is rejected in first difference in all of the variables except for $\Delta \ln k$ under the ADF, PP and KPSS where we did

3 These abbreviations are well known.

not report the results based on PP and KPSS. However, the two powerful tests viz., GLSADF and ERS show that $\Delta \ln k$ is a stationary variable. Therefore, we may conclude that we can proceed and utilize cointegration techniques to estimate the long run relationships between output and the other variables shown in Table 1.

Table 1. Unit Root Tests Results

VARIABLES	ADF	ADFGLS	ERS
ln (y)	-3.426 (-3.549)	-2.950 (-3.190)	7.007 (5.720)
ln (k)	-2.585 (-3.548)	-2.614 (-3.190)	6.481 (5.720*)
ln EX	-2.480 (-3.544)	-2.563 (-3.190)	9.295 (5.720)
ln AID	-1.749 (-3.544)	-1.127 (-3.190)	8.246 (5.720)
ln REM	-1.310 (-3.544)	-0.842 (-3.190)	5.725 (5.720)
D**ln (y)**	-4.247 (-2.951)	-4.313 (-1.951)	1.502 (2.970)
D**ln (k)**	-2.503 (-2.951)	-2.431 (-1.951)	2.939 (2.970)
D**ln EX**	-6.198 (-2.954)	-6.231 (-1.951)	0.659 (2.970)
D**ln AID**	-5.096 (-2.951)	-5.101 (-1.951)	1.495 (2.970)
D**ln REM**	-3.871 (-2.951)	-3.438 (-1.951)	1.793 (2.970)

Notes: Figures in brackets are the 5% level critical values. While in tests for the levels of the variables intercept and trend are included, trend is not present in the tests for their first differences. The null hypothesis in ADF and GLSADF is that the variable contains a unit root. In ERS the null is that the variable is stationary.

3.1 Cointegration

Where variables are in their levels I(1) and therefore I(0) in their first differences, means that such variables with a long run equilibrium relationship cannot drift very far apart because economic forces will act to correct any disequilibrium. In other words errors have a tendency to become small and will become I(0). Therefore, we now employ some popular techniques of cointegration to estimate a baseline long run output equation and then estimate the short run dynamic relationships based on the error correction adjustment model (ECM). GETS, Engle-

Granger, Fully Modified Ordinary Least Squares (FMOLS) and JMLVECM are used. However, only GETS and JMLVECM have given plausible results. These techniques will be used in the rest of this paper to examine whether or not variables like aid ratio, export ratio and remittance ratio have any effects besides the basic inputs of labour and capital. To conserve space we shall not report results with FMOLS and Engle-Granger methods.

3.2 The Model

In this empirical work, the basic Solow (1956) model and its extension by MRW is used. Therefore, some assumptions should be noted. Firstly, unlike in the cross section work with the Solow model where the steady state growth equation is estimated, in the time series what is estimated is the basic Cobb-Douglas production function and not the growth rate of output. Because of the transformations necessary to use time series methods (to overcome unit root problem), the dependent variable is the rate of growth of output. This does not mean that the estimated equation is the steady state growth equation and many applied workers mistake this to be so. This is not correct. What is estimated in time series models is the steady state production function. To derive steady state growth equation, this production function should be combined with other equations in the Solow (1956) growth model. Second, we also assume that there are constant returns and unlike in Solow (1956) technology is Hicks neutral. Third, additional variables, such as the export ratio etc., are introduced into the model as shift variables into the production function. We feel that this is adequate for our purpose although these additional variables can be introduced into the production function in other different ways. Essentially we follow Rao and Rao (2006) and our basic production function with constant returns and Hicks neutral technical progress is:

$$
\begin{aligned}
Y_t &= A_t\, K_t^{\alpha}\, L_t^{\,1-\alpha} \\
&= A_0 e^{gt}\, K_t^{\alpha}\, L_t^{1-\alpha} \qquad (1)
\end{aligned}
$$

where A_0 represents the initial stock of knowledge, t is time, K is capital and L is labour. An important assumption for illustrative purpose is that the stock of knowledge not only changes with time but also depends on a shift variable Z. For example this Z could be education or the ratio of exports or the ratio of aid to output etc. Now Z may have a permanent and/or a temporary effect on output. To distinguish between the temporary and permanent effects of Z, these following procedures are used. The first procedure is to include Z in the cointegrating equation with capital and labour inputs. The latter two variables may be treated as the conditioning variables. Omitting these conditioning could cause serious misspecification and the estimates are unreliable. If there is no cointegrating equation between Y, Z, K and L but there is a cointegrating equation with only Y, K and L, then Z has no permanent effects on Y.

The second procedure is that to test if Z has only a temporary effect, its rate of change and their lags may be included into the short run dynamic equation based on the lagged residuals of the cointegrating equation i.e., the error correction mechanism (ECM) adjustment process. If Z has no temporary effects, then changes in Z and its lagged values will have insignificant coefficients.

This specification (intercept and trend are ignored for convenience) based on the GETS approach where the long and/or short run effects of Z on Y can be captured and tested is as follows:

$$\Delta \ln Y = -\lambda(\ln Y_{t-1} - (\beta_1 \ln K_{t-1} + \beta_2 \ln L_{t-1} + \beta_3 \ln Z_{t-1})) + \sum\gamma_n \Delta \ln K_{t-n} + \sum\gamma_j \Delta \ln L_{t-j} + \sum\gamma_m \Delta \ln Z_{t-m} + \sum\gamma_j \Delta \ln Y_{t-(t-(1+j))} \quad (2)$$

If Z has both permanent and short run effects then b_3 and some g_m would be significant. If Z has only permanent effects only b_3 would be significant and if Z has only short run effects then b_3 would be insignificant while some g_m would be significant.

4. Empirical Results

4.1. The Solow Model with GETS

The London School of Economics-Hendry's general to specific approach (GETS) is widely used with its autoregressive distributed lag structure and the error correction mechanism of adjustment.[4] We shall estimate the GETS based specifications with the non-linear instrumental variable method to minimize endogeneity bias.

First, we estimate a baseline equation with only the two inputs viz., capital and labour. We include an intercept and trend and retrain the constant returns constraint, but without any Z shift variable. This yields the baseline estimate for subsequent comparisons. However, a shift dummy is included for a break in the intercept term because since 1990 there seems to be a break in the trends of many of our variables.[4] The specification for the baseline equation, with the well known transformation based on the constant returns assumption, is as follows.

$$\Delta \ln y_t = \alpha_0 + \alpha_1 T - \lambda(\ln y_{t-1} - (\beta_1 \ln k_{t-1})) + \sum \gamma_i \Delta \ln k_{t-i} + \sum \gamma_n \Delta \ln Y_{t-(n+1)} + \gamma DUM90 \quad (3)$$

where *DUM90* is one since 1990 and zero before and T is time trend. The lower case letters are in per worker values. Thus $y = (Y/L)$ and $k = (K/L)$ etc. The estimate of this baseline equation for the period 1973-2005 is as follows:

4 In our view in some respects GETS has been a better approach than the bounds test of Pesaran, Shin and Smith (1996) because there is no indeterminate range for the critical values of the cointegration test. Although originally there were no cointegration tests for GETS, recently Ericsson and MacKinnon (2003) have developed cointegration tests and these are similar to the well known cointegration test of MacKinnon (1991) for the Engle-Granger procedure. However, when our paper is almost completed, Professor Michael Sumner brought to our attention Turner (2006) in which a test similar to the MacKinnon (1991) was developed for cointegration in the bounds test. Unlike in the original Pesaran et.al asymptotic critical values, Turner has estimated critical values with adjustment for the sample size. This is a welcome addition because in the past some authors have made unsubstantiated claims that they have computed critical values for the bounds test with small samples.

4 Cointegration with unknown structural breaks is both hard and often misused. As far as we are aware, such tests were developed by Gregory and Hansen (1996) for only the Engle-Granger equations and there are no such tests for GETS. There is also a test for JMLVECM models when the break date is known a priori; see Jusilius (1996) and Joyeux (2007).

$$\Delta lny_t = 4.291 - 0.030T - 0.721(lny_{t-1} - .337lnk_{t-1}) + .467Dlny_{t-1} - 3.213Dlnk_{t-2}$$

(4.4)* (-5.3)* (7.5)* (3.0)* (6.9)* (-4.0)*

$$- 0.271dum90. \qquad (3b)$$

(-4.7)*

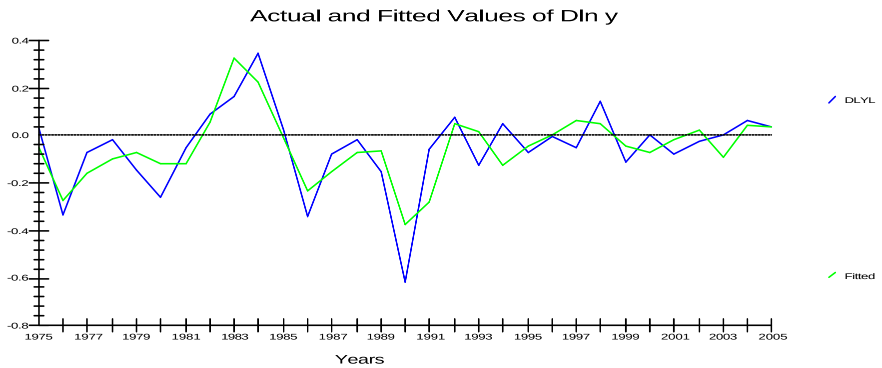
R bar^2 =0.53; GR bar^2=0.50, Sargan's ; ?^{2} (8)=8.850 [p=0.355]

SER=0.117; ?$^2_{sc}$=4.42 [0.035]; ?$^2_{ff}$ = 3.14 [0.076]; ?^2_n = 0.38 [0.83], ?^{2}h = 19.933 [0.00].

Notes: t-ratios are in the parentheses below the coefficients and * indicates significance at 5% level. The Chi-square (with p-values in square brackets are respectively: for the Sargan test for the choice of instruments, serial correlation, functional form misspecification, normality of residuals and heteroscedasticity.

The above estimate indicates that this baseline equation is satisfactory. All the coefficients are significant at the conventional 5% level. The R bar square and the GR bar square are close, indicating that the specification and the selected instrumental variables are appropriate. This is further confirmed by the Sargan Chi-square test, which is insignificant. The summary chi-square tests show that there is some serial correlation at the 5% but not at the 1% level. Because there is heteroscedasticity in the residuals, the t-ratios are White adjustment based. The standard error of the regression (SER), although high, is plausible for a small island country where output growth rate is highly volatile. In addition, the estimate of the adjustment coefficient lambda is highly significant with a t-ratio of 7.5, which exceeds the Ericsson-MacKinnon critical value at the 5% level. Thus per worker output and capital variables are cointegrated. The error correction coefficient is –0.721, which is less than one signifies that convergence to equilibrium will be smooth. Also, the dummy variable has a negative and significant coefficient implying that output has declined by 0.27 per cent since 1990 perhaps due to the following reasons. The government major commercial fishing company (Te Mautari Ltd) was closed down in late 1980s coupled with the cessation of phosphate mining for exports. Low world copra price prevailed affecting the copra industry (which is the main export of Kiribati after the closing down of phosphate mining) and an escalating trade deficit caused by the increasing imports of consumable items etc. Another noteworthy, although disappointing, finding is that the rate of total factor productivity (TFP) captured by the coefficient of trend (T) is negative implying that in Kiribati efficiency has declined with time at the rate of 3 per cent per year. This may be due to a lack of good management skills, closed down and unproductive investments and due to the immigration of skilled workers elsewhere. The implied profit share of 0.337 is plausible and very close to the stylized value of one-third in the growth accounting exercises. The actual and predicted values of output growth are shown below in Figure 1, which seems to be satisfactory.

Figure 1



4.2. The Solow Model with JMLVECM

Although the endogenous variable bias is minimized by the instrumental variables method in GETS, the Johansen systems method is more efficient compared to the single equations method of GETS. However, GETS estimates are very useful for selecting the options in the JMLVECM.[5] Our earlier GETS estimates imply that the order of VAR could be two and that both the intercept and trend may be retained in the selected VAR. One would get similar results with the order selection routines for the VAR. The only uncertainty is whether the intercept and trend should be constrained i.e., part of ECM or unconstrained i.e., outside ECM. Although this choice does not matter for GETS estimates, they do in JMLECM. However, according to what is known as the Pantula principle one should start with the unrestricted option first and if there is no cointegration then the restricted option should be tried; see Harris and Sollis (2005).

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5 Recently Sumner (2004) systematically outlined some difficulties in selecting the options in JMLVECM. However, Rao (2006) explains how GETS estimates can be used to select these options. This is not to say that JMLECM is the best technique. In practice it is better to use alternative cointegration techniques to prepare summaries of data for interpretation of the data. If alternative techniques yield similar summaries then our confidence in them improves.

Therefore, we have first used the unrestricted option and found one plausible cointegrating equation between $\ln y$ and $\ln k$ and the estimated cointegration equation is as follows[6]

$$\ln y = 0.535 \ln k \qquad (4)$$

Equation 4 implies that the share of profit is 0.535, which is higher than 0.337 of GETS, but this higher estimate is also plausible and the lower value in GETS may be partly due to some residual endogenous variable bias. The JMLVECM parsimonious dynamic adjustment equation for this version with the trend is as follows:

$$? \ln y = 2.24 - 0.02T - 0.525ECM_{t-1} - 2.39? \ln k_{t-1} - 0.23DUM90$$

$$(4.96)^{*} \quad (-3.48)^{*} \quad (-4.91)^{*} \quad (-2.67)^{*} \quad (-1.94)^{**} \qquad (5)$$

R bar^2= 0.439; SER=0.137;

$?^2_{sc}$= 1.2359[.266]; $?^2_{n}$=1.9869[.370] $?^2_{ff}$=11.4778[.001]; $?^2_{h}$=4.2993[.038]

* and ** indicate significance at the 5% and 10% level respectively.

The result from the above JMLVECM baseline equation is satisfactory. Although the R bar square is slightly less than the GETS equation, the actual and fitted values are reasonably good. As in the GETS equation, the dummy variable recorded a negative coefficient of -0.253 and the coefficient of trend is negative at -0.023 and are slightly differ from their GETS estimates. Thus this equation also implies that technical progress in Kiribati has been negative. Moreover, the coefficient of the error correction term in the JMLVECM is -0.53, which is similar to the ECM in GETS of -0.72, meaning that convergence to equilibrium will also be smooth but slower. The plot of actual and fitted values is in Figure 2.

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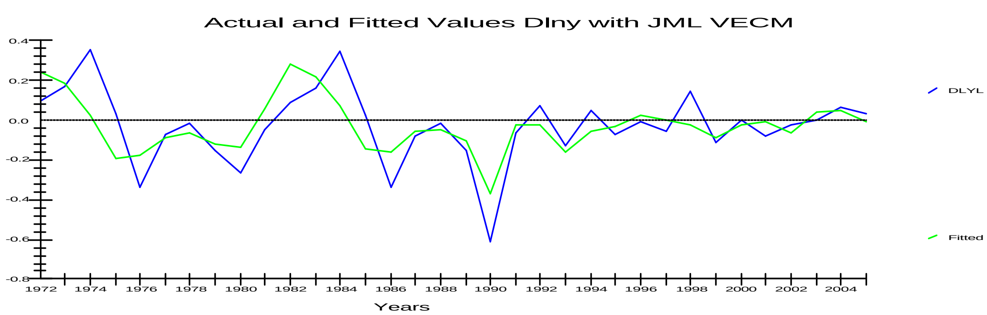
6 In the eigenvalue and trace tests the null of no cointegration is rejected. The computed test statistics, with the 95% critical values in the brackets are respectively, 20.325 (18.33) and 28.235 (23.80). The null that there is at least one cointegrating vector could not be rejected. The computed test statistics for these two tests are 7.91 (11.54) and 7.91 (11.54).

5. Extension to the Solow Model

The next task here is to extend to the Solow model to capture the effects of the aforesaid three shift variables viz., exports, aid and remittances. Using the GETS approach, the test is executed on variables like export ratio, ratio of aid to GDP and remittance ratio (ratio of remittance to employment) to examine whether they have any permanent and/or temporary effects on output. To conserve space we shall not report all the details, as none of these variables are found to have any meaningful positive permanent effects on output. These findings hold whether the GETS or JMLVECM method is used, although often JMLVECM yielded implausible estimates for the coefficient of ln k.[7] To conserve space, we shall only report results with GETS using the NLSQIV option in Mfit.

Figure 2



5.1. GETS Result with the Export Ratio

The estimated parsimonious equation where the export ratio has only temporary effects on output is as follows.

$$?\ln y_t = 3.5 - 0.027T - 0.66(\ln y_{t-1}) + 0.41\ln k_{t-1}) + 0.44?\ln y_{t-1} + -2.70?\ln k_{t-2} +$$

(3.4)* (-5.2)* (7.7)* (2.8)* (5.9)* (-3.5)*

$$-0.27Dum90 + \mathbf{0.046?}\ln EX \qquad (6)$$

7 Sumner (2004) warns about some difficulties with using JMLVECM in small samples.

(6.2)* (1.95)**

R bar^2 =0.55, GR bar^2 =0.493, Sargan's $?^2$ (4)=8.8668 [p=0.277];

$?^2_{ff}$ = 2.8[0.094]; $?^2_n$ = 0.42[0.809].=4.42 [0.035]; $?^2_{ff}$ = 3.14 [0.076]; $?^2_n$ = 0.38 [0.83], $?^2$h =20.362[0.00].

* and ** indicate significance at 5% and 10% levels respectively. T-ratios are White adjusted.

Compared to the baseline equation, without the export ratio, this equation is very close in all respects and only with minor changes to the estimated coefficients. The t-ratio of the adjustment coefficient implies cointegration at the 5% level. The share of profits increased marginally to 0.41 from 0.337. It is noteworthy that the coefficient of **?** lnEX is significant at only the 10% level. This equation implies that a 10% increase in export ratio will increase growth in output temporarily by about half a percent. Such low increase in output may be due to the fact that an increase in exports does not significant backward and forward linkage effects in Kiribati.

When the JMLVECM approach is used, the null hypothesis of no cointegration is rejected at the 5% and 10% levels but the null of one cointegrating vector is not rejected. However, the cointegrating vector showed that the coefficient of the export ratio is negative and the share of profit is 5.4 which is meaningless. Therefore, there is no meaningful long run relationship between the export ratio and output with this technique.

5.2. GETS Result with Aid

It is worth considering a GETS specification with aid, with linear and then a non-linear aid term because non-linear terms are often found in some *ad hoc* specifications in which there are no conditioning variables. However, only results with a linear aid term have been found to be significant and the estimate is given below.

$$\Delta \ln y = 2.93 - 0.04T - 0.73(\ln y_{t-1} + 0.65\ln k_{t-1} - 0.07\ln AID_{t-1})$$

(1.28) (-4.31) (5.56)* (1.96) (-2.46)**

$$+ 0.44\Delta \ln y_{t-1} - 3.69\Delta \ln k_{t-2} - 0.338Dum90 - 0.31\Delta \ln AID \qquad (7)$$

(3.36) (-4.49)* (-3.53)* (-1.81)*

R bar^2 = .23981; GR-bar^2 = .45515;SER = .14983; Sargan's $?^2$ (4) = 2.7161[.606]

$?^2_{sc}$ = 4.6579[.031]; X^2_{ff} = 3.1585[.076]; $?^2_n$ =.40260[.818]; $?^2_h$ = 4.2257[.040].

It can be seen that all the coefficients are significant although the share of profits are somewhat high at 0.65. The t-ratio of the adjustment coefficient implies that there is cointegration only at the 10% level. However, the effects of aid, in both long and short runs, are negative. It is pointless to think about how large are these negative effects and our results partly support Hughes (2003) concerns that aid has been unproductive in the Pacific Island Countries. Estimation on the effects of aid was also executed with JMLVECM but none of the options yielded any sensible results.

5.3. GETS Result with Remittances

GETS specifications with linear and non-linear remittance terms are estimated but the linear specification gave better results although the coefficient of capital became insignificant. Therefore, we re-estimated by constraining that the coefficient of capital is 0.337, which is the estimate in the baseline equation. The following is the result.

$$?\ln y_t = 5.39 - 0.033T - 0.83(\ln y_{t-1} - 0.337\ln k_{t-1} - 0.097\ln REM_{t-1}) + 0.41?\ln y_{t-1}$$

(5.97)* (-5.59)* (7.3)* (constrained) (4.6)* (-5.9)*

$$-0.38Dum90 - 0.335?\ln REM_t \qquad (8)$$

(-5.99)* (-1.4)

R bar^2=.48010;GR-Bar^2 =.53615; SER =.12391; Sargan's $?^2$ (4)= 6.918[.733]

$?^2_{sc}$=3.0260[.082]; χ^2_{ff}=4.8827[.027]; $?^2_n$=.50889[.775]; $?^2_h$ = 12.2192[.000].

The t-ratio of the adjustment coefficient implies cointegration at the 5% level. As can be noted the long run effect of remittance is negative and significant. Although its short run effect is negative it is insignificant. Therefore, we removed the short term effect and estimated the equation. However, the coefficient of remittance in the ECM has become insignificant. We also tried to estimate an equation in which remittance has only short run effect, but this equation was unsatisfactory and although the coefficients of the changes in remittances were negative they were all insignificant. Therefore, we may say that remittances like aid, have only negative permanent effects. It is difficult to explain why remittances have permanent negative effects unless, as the late Professor Kaldor once observed, in some countries people seem to prefer leisure to work. In other words what is implied is that the labour supply curve in Kiribati is perhaps backward bending.

5.4. Ad hoc Specifications

In order to get an idea of the nature of some *ad hoc* specifications without the two conditioning variables, we have used JMLVECM to test the effects of aid with a few typical and simple *ad hoc* specifications ignoring multiplicative terms.[5]

The assumed *ad hoc* specifications are: $\ln y = a + b \ln AID$ and $\ln y = a + b \ln AID + c \ln AID^2$. Application of the JMLECM technique showed that while there was no cointegrating vector in the linear specification, the trace and eigenvalue tests showed that there is one cointegrating vector in the non-linear specification. Normalized on output, this cointegrating equation is:

$$\ln y = 21.918 \ln AID - 1.583 (\ln AID)^2 \qquad (9)$$

This implies that the maximum effect of aid per worker reaches when log of aid per worker is about 7. The plot of this effect is given in Figure 3 below where x = log of aid per worker on the horizontal axis and on the vertical axis its effect on output worker is shown.

Although this result looks impressive it should be noted that the implied elasticity of output per worker with respect to aid per worker is implausibly high. In 2005 the value of log aid per

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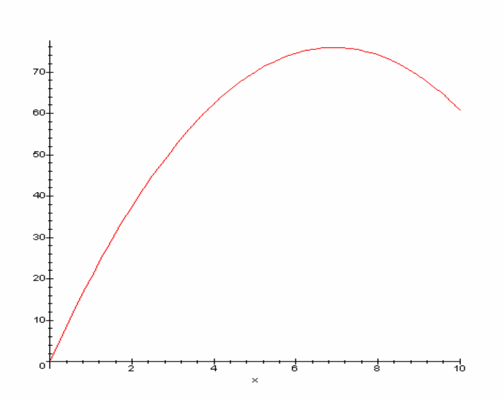
5 There are several other *ad hoc* specifications in which growth of output is simply regressed on aid etc and the equation is estimated with OLS. We shall not examine all such *ad hoc* specifications. An elaborate specification to determine the effects of aid in a time series model is Fenny (2005) for the PNG in which it was found that aid has no significant effect on growth. Although at times Fenny used 9 variables in the cointegrating vector, the two basic conditioning variables are not used in his specifications.

worker is 5.5765 and the elasticity at this value is 4.27, implying that a 10% increase in aid will cause about 43% increase in per worker output and such large effects of aid on output are difficult to believe.

Figure 3.



Finally, we have included exports, aid and remittances along with capital per worker and used JMLVECM to estimate a cointegration equation. Although we found one cointegrating equation, the coefficient capital became negative. Therefore, we have tried to estimate an equation with all these potential determinants of output with the NLLSQIV option and a GETS specification. Due to severe multi-collinearity between the variables the estimation failed. When the GETS specification is reestimated, without the instrumental variables method, the coefficient of capital was negative. When this coefficient was constrained to its value in the baseline GETS equation, the coefficients of exports, aid and remittances in the ECM term were all insignificant. Furthermore, the residuals of this equation are found to be serially correlated and therefore it is inappropriate to place any confidence in its summary statistics.

6. Conclusions

This paper explored the application of the Solow model and its extensions to Kiribati. In the empirical results, the Solow model baseline equation from GETS and JMLVECM are found to be satisfactory. The results for the Solow model show that the 1990 dummy variable has a negative and significant coefficient of 0.27, a kind of downward intercept shift in the production function due to increased inefficiency. Some possible reasons include: the failure of some Government enterprises such as Te Mautari Ltd and low world copra price on copra production and therefore low export earnings. Moreover, given the narrow export base, the trade deficit escalated, meaning that Kiribati depends heavily on overseas countries for aid in food and other consumer goods etc. Another noteworthy finding is that (based on the baseline results from the GETS and the JMLVECM), the rate of TFP captured by the coefficient of trend is negative, implying that Kiribati's efficiency has declined at the rate of 2 to 3 per cent per year. The implied profit share by the baseline GETS equation is plausible and very close to the stylized value of one-third in many growth accounting exercises. The lack of managerial skills, closed down businesses and unproductive investments, including the effect of brain drain are all plausible reasons for the decline in efficiency in Kiribati.

In terms of the extensions to the Solow model, aid ratio and export ratio did not have any permanent positive effects on output. In fact these two variables seem to have only permanent negative effects, lending support to Hughes' observation that aid has been counter productive in PICs. The effects of aid from our estimates are thus contrary to the result with some *ad hoc* specifications. However, the export ratio has a small temporary effect on output growth. aid ratio has a negative short run effect on growth, A 10% increase in the export ratio will temporarily increase per capita output by about 0.5. In conclusion, we may say that in Kiribati output in the long run and its growth in the short run are essentially determined by capital formation and therefore on investment.

There are a number of limitations in our study. For instance the available data on Kiribati cannot be claimed to be reliable and our specifications and estimation technique are with a small sample size. Therefore our study by and large is only exploratory. It is difficult to expect that more reliable data on Kiribati and many other PICs will become available in the near future, our findings should be treated with extreme caution.

Definitions and Data Sources

Y = Real GDP in 1991 prices

K = Capital stock estimated with the perpetual inventory method from data on total real investment. Depreciation rate is assumed to be 5% and the initial capital stock is assumed to be 1.2 times real GDP in 1970.

L = Employment in the formal sector

EX = Total exports divided by GDP

AID = Total foreign aid divided by employment

REM = Remittances made by Kiribati's labour employed overseas including merchant ships plus fishing license fees paid to Kiribati by overseas fishing trailers. It is measured in per employed worker.

Sources:

All GDP data are from the UN database at http://unstats.un.org/unsd/snaama/selectionbasicFast.asp
Data on employment, aid and remittances are estimated by Toani Takirua from various Government of Kiribati's publications.

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