



USPSE
SCHOOL OF ECONOMICS
UNIVERSITY OF THE SOUTH PACIFIC

WORKING PAPER

Estimating the Production Function for Fiji

Tausi Taupo

School of Economics

Faculty of Business and Economics

The University of the South Pacific

Suva

No. 2008/12

June 2008

This paper presents work in progress in the School of Economics at USP. Comments, criticisms and enquiries should be addressed to the author.

Copyright © 2008 by the author. All rights reserved.

Estimating the Production Function for Fiji

Tauisi Taupo¹

School of Economics
University of the South Pacific
Suva, Fiji

Abstract

Since the production function is a crucial macroeconomic relationship, it is the purpose of this paper to estimate the production function for Fiji applying General to Specific (GETS) and Fully Modified Ordinary Least Squares (FMOLS) time series techniques. This paper also examines the effects of trade openness on the growth rate of a small island economy like Fiji. The stability test shows that the production function for Fiji is temporally stable. The outcome estimates of capital share for Fiji was computed to be 0.19, labor share of 0.81 while trade share stands at 0.002 which are statistically significant with correct signs. Estimated results are consistent with both prior studies and the method engaged. However, they may differ in their precision but only marginally.

Keywords: Fiji, Production Function, Growth, GETS, FMOLS, Cointegration, Trade, Capital and Labor

¹ Tauisi Taupo is a Graduate Student at the School of Economics, the University of the South Pacific, Suva, Fiji. Email: jtaupo@gmail.com.

* I would like to thank Rup Singh for his guidance and useful comments on this paper. However, errors in this paper are entirely of the author's responsibility.

1.0 INTRODUCTION

The macroeconomic production function is the economic model that encompasses the various aspects of the concept most exhaustively, thus helping to grasp the meaning of potential output. The production function relates economy-wide income (or output) to the resources employed in generating it, hence potential output depends on the fundamental factors characterizing the respective economy that fall into several categories such as human resources (labor), means of production (capital) and total factor productivity, which is a catch-all for the remaining, often immeasurable, characteristics of the economy.

In this paper, we used the GETS and FMOLS methods to estimate the short-run and long-run relationships between the production function and its determinants for Fiji. As Smith (2000) pointed out, statistical techniques are only tools to summarize data and therefore they cannot answer difficult questions that need economic insights. He also added that there are three stages in applied work viz., purpose, summary and interpretation in which Rao (2006) shares a similar view. I believe that if alternative methods are employed properly with correct specifications they will consistently give similar summaries. Rao (2007) believes that cross-section studies may give some insights into growth enhancing policies but not useful to estimate country specific steady state growth rates (SSGRs) and identify policies to improve the SSGR thus suggesting that there are no country specific estimates of SSGRs and their determinants.

This paper extends the Solow model in order to capture and estimate the effects of trade by including it as a shift variable in the Solow equation.² Our objectives are to estimate the relevant elasticities derived from the production function, evaluate the stability of the production function due to its implications for the formulation of relevant policies, and to examine the effects of trade openness on the growth rate of a small island economy like Fiji. The main purpose of this paper are to estimate the parameters of the production function and compute the effect of trade on the growth rate of Fiji that in return could provide policy guidance.

The remainder of this paper is organized as follows. The following *Section 2* provides a brief literature survey on previous empirical studies on production functions in Fiji and

² Note that we are estimating an equation for aggregate output augmented with trade but not estimating the growth due to some unavoidable limitations.

other related works. *Section 3* presents the data and specification, *Section 4* reports our obtained results, present analysis on results based on time series techniques employed, explain and conduct identification and exogeneity tests, and examines the temporal stability of the production function while the final *Section 5* states the conclusion, policy implications with some limitations.

2.0 LITERATURE SURVEY

Many studies are available in the literature which estimates production function behavior, in particular, using various time series econometric techniques. Our standard long-run production function relates real output to capital stock and employment in which it was augmented to include trade openness in order to determine its effects on production growth. The existence of such a stable long-run aggregate production function is an important assumption of macroeconomic models. Furthermore, the quantitative estimates of the production function have important policy implications.

In the context of WTO and its rulings on developing countries, the Director General of the World Trade Organization (WTO) Pascal Lamy reported that “the GATT and the WTO have not done all they could, particularly for developing countries. In the coming months we have the chance to deliver more for our member governments and the citizens they represent. By striking an ambitious and development-oriented agreement in the Doha round we can greatly strengthen a system which has done much to make the world a better place.” According to the World Trade 2007 Report (2007) below:

“Special and differential (S&D) treatment provisions allow countries (often on a best-endeavour basis) to provide more favorable treatment to developing countries than to the remainder of the membership. Other provisions grant beneficiary developing countries rights that are not available to others. S&D is based on the assumption that developing countries are different from advanced economies and that temporary exemptions from the general rules (otherwise considered economically beneficial) constitute an appropriate response to particular development challenges. Developing countries may suffer from market imperfections and distortions not found in more advanced economies that obstruct their diversification into non-traditional activities. Resource constraints make it harder to adjust to the impact of trade liberalization, to

take advantage of new trading opportunities and to shoulder the costs associated with reform. While trade measures rarely present a first-best policy response, their use may be appropriate under certain circumstances and for a limited amount of time.”

Miller and Upadhyay (2000) studied the effects of openness, trade orientation, and human capital on total factor productivity for a pooled cross-section, time-series sample of developed and developing countries. They used panel data that combines data in five-year blocks to estimate the production function in which data cover 1960 to 1989 for 83 countries from the following regions: Africa (19 countries), Caribbean, Central America, and North America (11), South America (11), Asia (16), Europe (20), and Oceania (4). They first estimated total factor productivity from a parsimonious specification of the aggregate production function involving output per worker, capital per worker, and the labor force, both with and without the stock of human capital. Then they consider a number of potential determinants of total factor productivity including measures of openness, trade orientation, and human capital. They relayed that a higher openness benefits total factor productivity, hence an outward-oriented country experiences higher total factor productivity, over and above the positive effect of openness. They concluded that human capital generally contributes positively to total factor productivity, in the case of poor countries however, human capital interacts with openness to achieve a positive effect.

Soderbom and Teal (2003) examines whether or not openness to trade and higher levels of human capital could promote faster productivity by using a panel data on 93 countries spanning every fifth year during the 1970 to 2000 period. They control for fixed effects as well as endogeneity, the results show a significant effect of openness on productivity growth. They suggested that if the level of openness of an economy is doubled the underlying rate of technical progress will increase by 0.8 percent per annum. They found an effect, significant at the ten per cent level, of the level of human capital on the level of income but no effect on underlying productivity growth. They concluded that there is a significant effect of openness on productivity growth. They also criticized that models such as many specifications of the Solow model which assume this rate to be constant cross countries may be misleading in any analysis of the determinants of growth. The estimated coefficient on the trade share is equal to 0.7, and highly significant, and the population coefficient is positive although not significant at conventional levels which is a very large

effect indeed. They obtain capital-ratio estimate of 0.35, which is plausible compared to similar studies.

Rao and Rao (2005) used the neoclassical production function based on the Solow model applying GETS and FMOLS methods to illustrate the effects of trade openness on the growth rate using data from Fiji for the period 1970 to 2002. They tested all variables for unit roots and found to be $I(1)$ in levels and $I(0)$ in their first differences. They also employed CRADF test where their null of no cointegration was rejected. They also estimated the production function in per worker terms whereby the dependent variable became $\ln(Y/L)$ and the explanatory variable is $\ln(K/L)$. The estimated share of profits was about 0.3 which was significant with correct signs. Their concluding empirical results imply that a 10% increase in trade openness may increase growth rate by about 2% in the case of Fiji as they see the significance of further improvements to be made to understand country specific growth determinants with time series approaches. They also mentioned that within their approach it implies that human capital is a relatively more important shift variable than trade openness. Their results indicate that about 70% variation in the growth rate can be explained with factor accumulation and trade openness as compared to Mankiw, Romer and Weil (1992), MRW henceforth, whom their cross section study has explained about 80% variation in the growth rate when the neoclassical production function was augmented with human capital. However, they confirmed that it is hard to draw conclusions on the relative importance of alternative shift variables until additional shift variables are identified and analyzed to show that the Solow residual can be significantly reduced.

Rao, Singh and Nisha (2006) further extend the growth model to capture their permanent growth effects. Time series data for Fiji from 1970 to 2002 are used to show that the growth effect of human capital, although small, is significant. They used GETS method, and a constant returns Cobb-Douglas production function with the Hicks neutral technical progress. They estimated capital share at about 0.20, labor share at about 0.70. They also included a dummy variable representing coup that was significant at about 0.004. All of its coefficients are significant and the summary χ^2 test statistics are all insignificant. They also tested for cointegration by using the Ericsson and Mackinnon test at 5% where the null of no cointegration was rejected. However, they concluded that in Fiji the growth

effects of human capital clearly dominated its level effects, therefore, these growth effects are very small, but significant.

Rao and Singh (2008) in their paper used time series panel data methods to estimate the contribution of openness of trade to total factor productivity of six East Asia countries with data from 1971 to 2004 for Singapore, Malaysia, Thailand, Hong Kong, Korea and the Philippines which have grown rapidly with an average of 3.5% per year. Among some crucial growth factors, trade openness is considered to be important for the rapid growth of East Asian countries. They examine the role of openness in the growth process of this region. They used the first generation panel cointegration tests and the Group-Mean Panel Fully-Modified Ordinary Least Squares (GMPFMOLS) method. They employed the standard Cobb-Douglas production function with constant returns and the Hicks neutral technical progress with extension of the Solow model in order to capture trade openness in the context of per worker output and per worker capital. Their preferred results show that about 95% of TFP in East Asian is due to trade openness. Some limitations encountered are due to their small sample of 240 by the standards of many panel data studies and the fact that they have ignored other factors that may influence TFP.

3.0 EMPIRICAL SPECIFICATION AND DATA

The widely applied specification of the Solow model was adopted in which the growth rate of output in the non-steady state depends on the rates of growth of the factors of production (capital and labor) and the technology residual. In the context of the neoclassical production function, the level of output (Y) depends on the levels of capital stock (K), employment (L) and the stock of technology (A). However, this paper will be using a similar specification outlined by Rao and Rao (2005) and Rao and Singh (2008). Our standard specification is illustrated below while extending it to capture trade openness as a shift variable:

$$Y_t = A_0 e^{gT} K^\alpha L^{1-\alpha} \quad (1)$$

where Y is output, K is capital and L is employment. The coefficient of trend g captures the rate of technical progress (TFP) and A_0 is the initial stock of capital.

Descriptions of the variables and sources of data are in *Appendix A1*. Equation (1) could further be modified in order to add trade (TR) as a shift variable as shown in (2) below:

$$Y_t = A_0 e^{(g+g_1 TR)T} K^\alpha L^{1-\alpha} \quad (2)$$

We assume a log-linear relationship for (2) with a single shift variable of trade openness (TR), therefore (2) can be then expressed as (3) below:

$$\ln Y_t = \ln A_0 + (g + g_1 TR_t)t + \alpha \ln K_t + (1 - \alpha) \ln L_t + \varepsilon_t \quad (3)$$

The estimation technique employed in this paper is the GETS approach which is an extensively used autoregressive distributed lag specification with Error Correction Model (ECM). Nevertheless, our specification in (3) will then be expressed in first difference of time to give:

$$\Delta \ln Y_t = -\lambda [\ln Y_{t-1} - (\ln A_0 + (g + g_1 TR_{t-1})t + \alpha \ln K_{t-1} + (1 - \alpha) \ln L_{t-1})] + ARDLs \quad (4)$$

Table 1 reports the cointegrating coefficients obtained from this method. It shows the long-run estimates for GETS which are obtained after subjecting the variables to unit root tests. According to *Table 3* in *Appendix A2*, all tested variables in (1) for unit roots in the series were done using Augmented Dickey Fuller (ADF) test that were found to be I(1) in levels and I(0) in first difference. Unit root tests were conducted on these time-series to investigate whether they are stationary or not. An ADF type test called the CRADF test was used with the null hypothesis that the variables are not cointegrated, that is the residuals are I(1).³

Ericsson and MacKinnon (2002) have developed cointegration tests for specifications like GETS where we tested the null of no cointegration to be rejected at 5%.⁴ The Ericsson & Mackinnon (EM) critical value that was computed for 5% significance stands at -4.07

³ The lag lengths were selected using AIC and SBC criteria. The CRADF statistic value at 5% significant level is -5.410 which is higher than the test statistic at -4.976 in absolute terms. Therefore, we accept the null hypothesis that the variables are not cointegrated. Details are available from author on request.

⁴ The adjusted sample size is $T^a = T - [2(k) - 1] - d$ which is computed as $T^a = 36 - [2(3) - 1] - 2 = 29$.

Therefore, we substitute values from the EM table to compute the finite sample CV with the formula

$q(T_i) = \theta_\infty + \theta_1(T_i^\alpha)^{-1} + \theta_2(T_i^\alpha)^{-2} + \theta_3(T_i^\alpha)^{-3} + u_i$ that resulted to be

$q(T_{31}) = -3.9263 - 4.47(29)^{-1} + 5.2(29)^{-2} - 38(29)^{-3} + 0.00474 = -4.07$

which is lower in absolute terms if compared to t-ratios of our Lambda⁵ in GETS or ECM of residuals at 1 lag period in FMOLS in *Table 2*. Nevertheless, it implies that they are eligibly significant at 5% level thus demonstrating that cointegration exist in the long-run relationship between the variables included in the ECM.

The statistical data used in this paper were obtained from the International Financial Statistics (IFS) published by the IMF. Other relevant data were obtained from the ADB Statistics, UN Database, PIDS Economic & Social Database and data from the Reserve Bank of Fiji (RBF). The sample period for estimation is 1970 to 2005. Generally, the real output in the production function in our case is expected to respond positively to an increase in respective capital and employment.

4.0 EMPIRICAL RESULTS AND ANALYSIS

4.1 Identification and Exogeneity Tests

The identification tests indicate that all the implied long-run relations represent production function, since only the one period lagged residuals normalized on production ($ECMY_{t-1}$) was significant with correct negative signs in $\Delta \ln Y_t$ equations. Moreover, all the residuals normalized on capital $ECMK_{t-1}$, on labor $ECML_{t-1}$ and trade $ECMTR_{t-1}$ were insignificant in their respective regressions. The computed ECM coefficients and their t-ratios in parenthesis are reported in the diagonal of their respective (4×4) matrices in *Table 4* in *Appendix A2*.

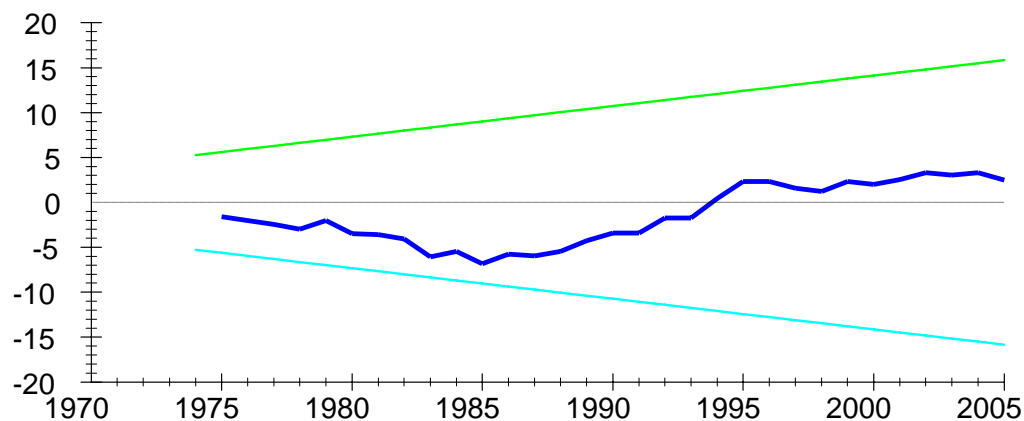
Following Enders (2004), another set of four ECM equations were estimated with their respective $ECMY_{t-1}$ being included as one of the independent variables in each of the implied equations. The $ECMY_{t-1}$ was only significant in equations where the dependent variables were $\Delta \ln Y_t$ in all cases. The exogeneity test results are also illustrated in *Table 4* if you observe along the first row in the matrix. Since the disequilibrium do not significantly contribute to the explanation of $\ln K_t$, $\ln L_t$ and TR_t in all cases, we treated $\ln K_t$, $\ln L_t$ and TR_t as being weakly exogenous in respective to the production function

⁵ Lambda is denoted by λ in *Table 2*.

equation. Using the one period lagged residuals from the above cointegrating relations, the dynamic production function equations was estimated. Unlike FMOLS and other alternative methods, GETS estimates both the equilibrium relation and the dynamics in one step.

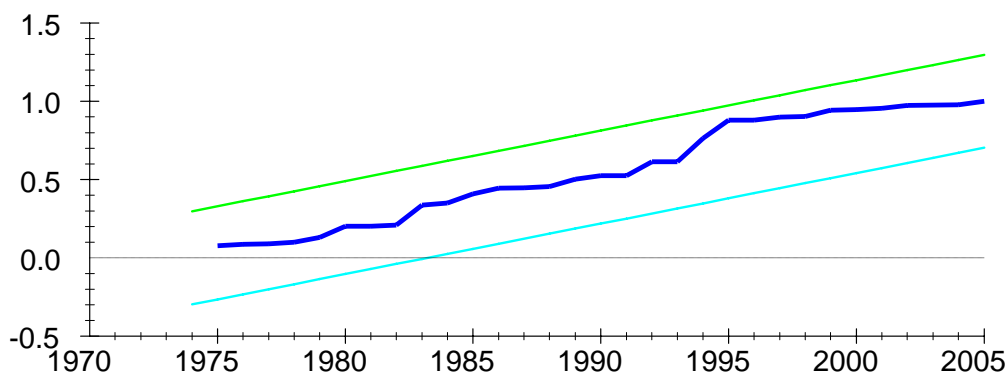
4.2 Stability Tests

Figure 1: Plot of Cumulative Sum of Recursive Residuals for GETS



The straight lines represent critical bounds at 5% significance level

Figure 2: Plot of Cumulative Sum of Squares of Recursive Residuals for GETS



The straight lines represent critical bounds at 5% significance level

It is vital to test for stability of the production function after obtaining our equilibrium estimates and dynamic equations. The *CUSUM* and *CUSUM Squares* tests for GETS does not show evidence of instability in our production function equation as relayed by *Figure 1* and *Figure 2*, thus indicating that our sound estimates are temporally stable hence showing the existence of a stable relationship between the variables that enters the production function equation. The CUSUM and CUSUM Square test results for FMOLS also support

the existence of a stable relationship but were not included in this paper to conserve space.⁶

4.3 Estimated Outcomes

Having confirmed and satisfied the two conditions of exogenous and identification tests with stability tests, the dynamics of LY equation in the second stage was performed using ARDL of 4th order whereby a parsimonious equation (best dynamic structure) was developed using the GETS method by deleting the insignificant variables from the dynamic equation for LY. FMOLS method was also employed. This was further improved with some parameters restrictions. A dummy representing the two political coups on the supply side was put to the test that shows a temporary negative effect of -0.003 which was significant at 10%.

In this section we will present our empirical results. *Table 1* shows the GETS estimated cointegrating coefficients of the production function for Fiji which outlines the implied long-run coefficients obtained from the error correction part given by the lagged levels of the variables.

Table 1: Cointegrating Coefficients of the Production Function for Fiji	
Variable	GETS
<i>Constant</i>	-3.543 (-6.72)*
$\ln K_{t-1}$	0.190 (3.88)*
$\ln L_{t-1}$	0.810 (c)
TR_{t-1}	0.002 (3.69)*

Notes: The t-ratios are reported in brackets below the coefficients and significance at 5% and 10% are indicated by * and ** respectively. The sample period taken are 1970 to 2005. Constraint estimates are indicated with (c). Microfit 4.1 of Pesaran and Pesaran (1997) is used for estimation.

Table 1 implies that we have a long-run capital share and trade share computed at 0.19 and 0.002 respectively, with expected signs which are statistically significant. The production function was also estimated in per worker terms, where we obtained a capital per worker's share of 20% which fall reasonably close to stylized values of 25% to 30% for developing countries.⁷ Without trade, growth is as high as 1%. We can say that if

⁶ CUSUM and CUSUM Squares test results for FMOLS are available upon request from author.

⁷ Computed using GETS with a non-linear regression formula:

$\Delta \ln YL_t = \lambda [\ln YL_{t-1} - (\ln A_0 + gT + \alpha_1 \ln KL_{t-1})] + \beta_1 \Delta \ln KL_t$. Since A_0 is the constant, therefore log of a

trade is raised by 1%, it will raise Fiji's growth rate by about 0.3%.⁸ It is also evident that trade captures about 30% of Solow residual (or growth) while about 60% is unknown. We cannot deny the presence of non-linear growth effects which reveal that it takes about 2 years for the growth effects to perish.⁹ However, this paper found out very similar and comparable results with previous studies.

Some coefficients were restricted to obtain their preferred equations. The *SERs* in all estimates are low and the ECM_{t-1} terms are strongly significant with correct negative signs implying negative feedback mechanisms in all dynamic equations. The fitness of the actual vs. predicted values of growth of real output gives fairly reasonable \bar{R}^2 for all and *SEEs* are low. The data on *Table 2* outlines our estimates of the dynamics of the production function equations using the GETS and FMOLS methods. Note that none of the χ^2 summary statistics are significant at 5% level, therefore assuming that our estimations does not encounter any problems from serial correlation, functional form misspecification, non-normality and heteroscedasticity in residuals. However, other subsequent variables included in our preferred estimates are highly significant as well.

constant is a constant which in our case will be captured by the constant term in the regression denoted by C. This was not reported to conserve space but available upon request from author.

⁸ Estimating the effects of trade on growth rate of output $\Delta \ln Y^* = g + g_1 \Delta \bar{TR} = 0.0025 + 0.002(0.07) = 0.003$.

⁹ Computed as $\Delta \ln Y^* = g + g_1 \Delta \bar{TR} = 0.0093 - 0.0046 \Delta \bar{TR}$, making $\Delta \ln Y^* = 0$ results in $\Delta \bar{TR} = \frac{-0.0093}{-0.0046} = 2.02$.

Table 2: Short-Run Dynamic Production Function Equations

	GETS (NLLS)				FMOLS	
	A1	A2	A3	A4	A5	A6
<i>Constant</i>	-3.739 (-6.36)*	-3.975 (-6.41)*	-3.450 (-6.51)*	-3.543 (-6.72)*	0.038 (4.32)*	0.041 (4.61)*
<i>Trend</i>	0.008 (5.15)*	0.009 (9.32)*	0.002 (5.04)*	0.0025 (c)		
$\ln K_{t-1}$	0.157 (3.61)*	0.197 (5.10)*	0.186 (3.78)*	0.190 (3.88)*		
$\ln L_{t-1}$	0.843 (c)	0.803 (c)	0.814 (c)	0.810 (c)		
$\ln TR_{t-1}$		0.009 (c)				
TR_{t-1}			0.002 (c)	0.002 (3.69)*		
λ	-1.103 (-6.09)*	-1.205 (-6.44)*	-0.847 (-4.59)*	-1.104 (-6.26)*		
$\Delta \ln Y_{t-4}$	-0.217 (-2.03)*		-0.125 (-2.36)*	-0.116 (-2.18)*		
$\Delta \ln K_t$	0.767 (3.14)*	0.829 (3.12)*	0.634 (2.64)*	0.656 (2.81)*	0.939 (4.02)*	1.127 (4.95)*
$\Delta \ln K_{t-1}$					-0.613 (-3.04)*	-0.683 (-3.49)*
$\Delta \ln K_{t-2}$	-0.271 (-2.29)*		-0.428 (-3.16)*	-0.407 (3.13)*		
$\Delta \ln K_{t-3}$					-0.202 (-2.29)*	-0.239 (-3.44)*
$\Delta \ln K_{t-4}$	-0.271 (c)		-0.428 (c)	-0.407 (c)		
$\Delta \ln L_t$	0.665 (4.84)*	0.700 (4.94)*	0.631 (4.65)*	0.654 (4.85)*	0.528 (4.40)*	0.623 (5.53)*
$\Delta \ln L_{t-2}$	-0.271 (c)		-0.307 (-2.39)*	-0.306 (-2.45)*	-0.202 (c)	-0.143 (-2.66)*
$\Delta \ln L_{t-4}$	-0.189 (-1.87)**		-0.245 (-2.60)*	-0.239 (-2.62)*		
$\Delta \ln TR_{t-3}$		-0.118 (-1.77)**				
ΔTR_{t-1}						-0.143 (c)
ΔTR_{t-3}			-0.125 (c)	-0.116 (c)	-0.216 (-3.02)*	-0.239 (c)
COUP					-0.003 (-1.87)**	
ECM_{t-1}					-1.002 (-3.02)*	-1.142 (-7.52)*
\bar{R}^2	0.654	0.607	0.662	0.673	0.694	0.713
SSE	0.026	0.028	0.026	0.026	0.025	0.024
$\chi^2(sc)$	1.218 [0.27]	0.001 [0.98]	1.928 [0.16]	2.536 [0.11]	1.571 [0.21]	0.669 [0.41]
$\chi^2(ff)$	1.218 [0.27]	0.099 [0.75]	0.00 [1.00]	0.022 [0.88]	0.015 [0.90]	0.088 [0.77]
$\chi^2(n)$	2.004 [0.37]	0.195 [0.91]	2.338 [0.31]	3.070 [0.22]	1.401 [0.50]	1.429 [0.49]
$\chi^2(hs)$	0.130 [0.72]	0.017 [0.90]	0.001 [0.98]	0.002 [0.97]	0.097 [0.76]	0.069 [0.79]

Notes: The t-ratios are reported in parentheses below the coefficients and significance at 5% and 10% are indicated by * and ** respectively. The chi-square tests in order of presentation in the table are for serial correlation, functional form misspecification, non-normality and heteroscedasticity in residuals for which corresponding p-values are in square parenthesis. Constraint estimates are indicated with (c). Microfit 4.1 of Pesaran and Pesaran (1997) is used for estimation.

The dependent variable is $\Delta \ln Y_t$. Equation (A1) estimated the Solow equation without trade with constant returns assumption indicating a share of capital at 0.16. The coefficient of trend indicates that technical progress is very low at 0.8 percent per year. While estimating equation (A2) where trade was introduced as a shift variable, we acquired an increase in share of capital to 0.20 while the trend and share of trade coefficients both stands at 0.009. All of its coefficients are significant and the χ^2 test statistics are all insignificant. Equation (A3) introduces trade as a LGP shift variable that estimates a lower share of trade at 0.002 with a coefficient of 0.19 for trend. In Equation (A4), we constrained the value of productivity to 0.0025^{10} where we obtain almost same coefficients for share of trade and trend as in (A4) but differ only marginally. All equations possess reasonable \bar{R}^2 and SSE. Equations (A5) and (A6) were estimated using FMOLS method where a dummy representing political coups in (A5) was inserted to the equation. Note that it was difficult to empirically estimate MRW type with trade as a shift variable with GETS due to collinearity problems, therefore, only the long-run was estimated but not reported to conserve space.¹¹ The results are very similar to other specifications in *Table 2* but differ only marginally.

The results have usual interpretation indicating that trade and capital stock have short-run positive effects and coup seems to have temporary negative effects on output, not on growth rate. The capital share is 20% and not far from the stylized value of 30%. The exogenous technical progress rate is 1% per annum.

¹⁰ However, a Wald test was performed on the null that the g is equivalent to 0.0025 where it was not rejected at 10%, indicating that they are similar, therefore g was constraint to be equal to 0.0025 in Column (A4).

¹¹ The non-linear regression formula for MRW is $\ln Y_t = \ln A_0 + gT + \alpha_1 \ln K_t + \alpha_2 \ln L_t + (1 - \alpha_1 - \alpha_2) \ln TR$

4.4 Actual vs Fitted Values

Figure 3: Plot of Actual and Fitted Values

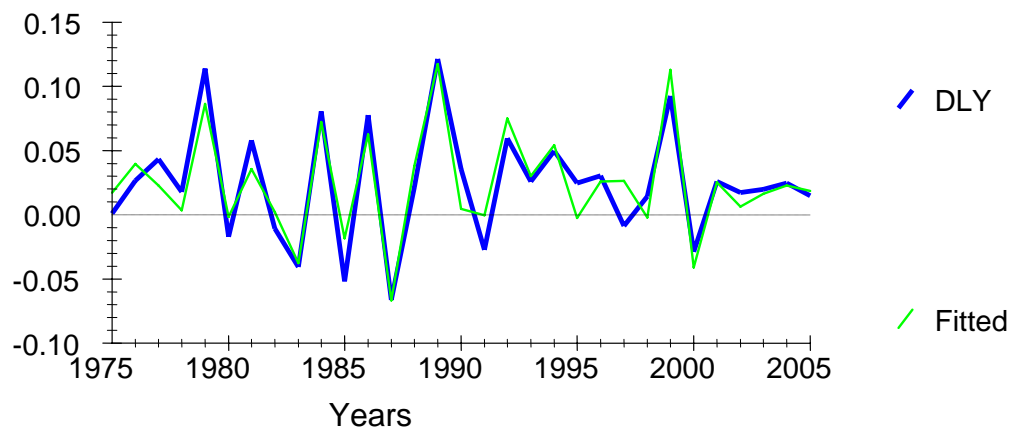


Figure 3 above show the plot of actual and predicted values of our preferred estimates indicating that they predict changes in the production function reasonably well. It is also evident that our obtained results from our time series technique applied are consistent with previous studies and our expectations.

5.0 CONCLUSION AND POLICY IMPLICATIONS

In this paper we empirically revealed that production function relation is well determined by the two crucial long-run elasticities of capital and labor. Our empirical results based on GETS approach conclude that our long-run shares for capital, labor and trade are 0.19, 0.81 and 0.002 respectively, which are statistically significant with expected signs. However, the *CUSUM* and *CUSUM Squares* stability tests show that the production function is temporally stable with the existence of a stable relationship between the variables that enter the production function equation. A *dummy* variable representing the two major coups in Fiji was put to the test that shows a temporary negative effect on output at -0.003.

Nevertheless, the coefficients for ECM are statistically significant as expected thus supporting the validity of the equilibrium relationship between the variables in the long-run equations. The speed of adjustment (λ) which measures how quickly adjustments to equilibrium take place is close to unity with expected signs and significant statistics indicating that the relation will converge thus signaling that the long-run equilibrium is stable.

It is vitally important for applied economists to carefully understand the theories, models and time series techniques to prevent unwarranted conclusions leading to further policy dilemmas. The important issue is to have the right specifications for estimations in order to base our policies on good predictions. Estimations of this nature help policy makers in addressing policy questions and that, for these, predictive accuracy is paramount. It is imperative that our specifications and results are consistent with economic theory. The existing estimated elasticities are of crucial vitality which enables us to translate assumptions about future expectations into actual projections that could anticipate the implications for economic performance and design alternative policy responses. Further research and analysis are necessary for better empirical estimation that may allow these results to be further refined in future work, hence better determination of production growth policies. One limitation present in this paper is the ignorance of possible structural breaks and their implications on unit root tests.

Data Appendix A1

Y is the real gross domestic product (GDP) in 2000 prices. Data are from International Financial Statistics (IFS) 2005 and UN Database.

K is capital stock, estimated with the perpetual inventory methods with the assumption that the depreciation rate is 4%.

L is employment and these are from the Fiji Bureau of Statistics (BOS) and Reserve Bank of Fiji (RBF) publications.

TR is trade computed as a ratio of total exports of goods and services plus imports of goods and services on GDP. Data are obtained from IFS 2005 and UN Database.

Sources: Data are from IMF IFS 2005 Data, UN Database, ADB Database, Fiji Bureau of Statistics and RBF Statistics.

Appendix A2

Table 3: Augmented Dickey-Fuller (ADF) Unit Root Test for variables entering the Production Function Equation

	$\ln Y_t$	$\Delta \ln Y_t$	$\ln K_t$	$\Delta \ln K_t$	$\ln L_t$	$\Delta \ln L_t$	TR_t	ΔTR_t
Lags	[0,0]	[0,0]	[1,1]	[0,0]	[0,0]	[1,1]	[0,0]	[0,0]
Test Statistic	-2.626	-8.492*	-2.846	-3.573*	-3.051	-5.403*	-2.337	-5.568*

Notes: The ADF is the augmented Dickey-Fuller test. Significance at 5% level is indicated by *. The 5% critical value for ADF is -3.567. The lag lengths are selected using AIC and SBC criteria, for example [0,1] indicates that lag 0 and 1 are significant in the respective tests. If the ADF statistic is higher than the Test statistic in absolute terms then it relays that there is unit root presence. The sample period taken are 1970 to 2005.

Table 4: Identification and Exogeneity Tests

	$\Delta \ln Y_t$	$\Delta \ln K_t$	$\Delta \ln L_t$	ΔTR_t
$ECMY_{t-1}$	-0.827 (-4.24)*	0.085 (0.43)	0.411 (1.37)	0.552 (1.43)
$ECMK_{t-1}$		-0.132 (-1.37)		
$ECML_{t-1}$			-0.271 (-0.90)	
$ECMTR_{t-1}$				-0.111 (-1.06)

Notes: The t-ratios are reported below the coefficients and significance at 5% and 10% are indicated by * and ** respectively. $ECMY_{t-1}$, $ECMK_{t-1}$, $ECML_{t-1}$ and $ECMTR_{t-1}$ are the lagged residuals of the CVs normalized on output, capital, labor and trade, respectively. The sample period taken are 1970 to 2005.

References

- Duraluf, N., Johnson, A., and Temple, W., (2004) "Growth econometrics," forthcoming,: Handbook of Economic Growth.
- Enders, W., (2004) "Applied Econometric Time Series," 2nd edition, Hoboken NJ: John Wiley.
- Ericsson, N., and MacKinnon, J., (2002) "Distributions of Error Correction Tests for Cointegration," *Econometrics Journal*, 5: 285-318.
- Friedman, M., and Schwartz, A., (1991) "Alternative Approaches to Analyzing Economic Data," *American Economic Review*, 81(1): 39-49.
- Gong, G., Greiner, G., and Simmler, W., (2004) "Endogenous growth: estimating the Romer model for the US and Germany," *Oxford Bulletin of Economics and Statistics*, pp. 147-164.
- Gonzalo, J., (1994) "Five Alternative Methods of Estimating Long Run Equilibrium Relationship," *Journal of Econometrics*, 60, 203-233.
- Hall, E., and Jones, I., (1999) "On the limitations of government borrowing: A framework for empirical testing," *Quarterly Journal of Economics*, pp.83-116.
- International Financial Statistics, December, 2003/5. IMF CD-ROM (Washington DC: International Monetary Fund).
- Johansen, S., (1988) "Statistical Analysis of Cointegrating Vectors," *Journal of Economics Dynamics and Control*, pp.231-254.
- Jones, I., (1995) "Time series tests of endogenous growth models," *Quarterly Journal of Economics*, pp. 495-525.
- Mankiw, G., Romer, D., and Weil, D., (1992) "A contribution to the empirics of economic growth," *Quarterly Journal of Economics*, pp.407-437.
- Miller, S., and Upadhyay, M., (2000) "The Effects of Openness, Trade Orientation, and Human Capital on Total Factor Productivity," Working Paper (05/2000). USA: The University of Connecticut.
- Pesaran, H., and Pesaran, B., (1997) "Working with Microfit 4.0," (Oxford: Oxford University Press).
- Rao, B., (2005) "Estimating Short and Long Run Relationships: A Guide to Applied Economists," Staff Working Paper (16/2005). Suva: The University of the South Pacific.
- Rao, B., (2006) "Time Series Econometrics and Applied Economics: A Methodological Perspectives," forthcoming: *Indian Journal of Economics and Business*, June 2006.
- Rao, B., and Rao, M., (2005) "Determinants of Growth Rate: Some methodological issues with data from Fiji," Staff Working Paper (23/2005). Suva: The University of the South Pacific.
- Rao, B., and Singh, R., (2008) "Contribution of Trade Openness to Growth in East Asia: A Panel Data Approach," Staff Working Paper (03/2008). Suva: The University of the South Pacific.
- Singh, R., and Kumar, S., (2006) "Demand for Money in developing countries: Alternative estimates and policy implications," Staff Working Paper (05/2006). Suva: The University of the South Pacific.

- Smith, R., (2000) "Unit Roots and all That: The Impact of Times Series Methods on Macroeconomics," in Backhouse, R. and Salanti, A. (eds). Macroeconomics and the Real World, Oxford: Oxford University Press.
- Soderbom, M., and Teal, F., (2003) "Openness and Human Capital as Sources of Productivity Growth: An Empirical Investigation," Working Paper (06/2003). UK: University of Oxford.
- Solow, M., (1956) "A Contribution to the theory of economic growth," Quarterly Journal of Economics, pp. 65-94.
- Parente, J., (2001) "The failure of endogenous growth," Unpublished manuscript, University of Illinois at Urbana-Champaign.
- Pesaran, M., and Smith, J., (1994) "A generalised \bar{R}^2 criterion for regression models estimated by the instrumental variables method," Econometrica, pp.705-10.
- World Trade Organisation., (2007) "World Trade 2007 Report: Six Decades of Multilateral Trade Cooperation: What have we learnt?," WTO Publications, Switzerland.

Recent Working Papers

2008/wp

- 11 Tauisi Taupo, Estimating demand for money in Philippines.
- 10 Filipo Tokalau, The Road that is; for whom and why: Impacts of tourism Infrastructural development on Korotogo Village, Fiji islands.
- 9 Mahendra Reddy, Sequential Probit modeling of the determinants of child Labour: Is it a case of luxury, distributional or Substitution Axiom?
- 8 Neelesh Gounder, Mahendra Reddy and Biman C. Prasad Support for Democracy in the Fiji Islands: Does Schooling matter?
- 7 Sunil Kumar Fiji's declining formal sector economy: Is the informal sector an answer to the declining economy and social security?
- 6 T K Jayaraman and Evan Lau Does External Debt Lead to Economic Growth in the Pacific Island Countries: An Empirical Study
- 5 Gyaneshwar Rao The Relationship between Crude and Refined Product Market: The Case of Singapore Gasoline Market using MOPS Data
- 4 Bill B Rao and Saten Kumar A Panel Data Approach to the Demand for Money and the Effects of Financial Reforms in the Asian Countries
- 3 Bill B Rao and Rup Singh Contribution of Trade Openness to Growth in East Asia: A Panel Data Approach
- 2 Bill B Rao, Rup Singh and Saten Kumar Do We Need Time Series Econometrics?
- 1 Rup Singh and Biman C Prasad Small States Big Problems Small Solutions from Big Countries

2007/wp:

- 24 Biman C Prasad Changing Trade Regimes and Fiji's Sugar Industry: Has the Time Run-out for Reform or is there a Plan and Political Will to Sustain it?
- 23 B Bhaskara Rao and Rup Singh Effects of Trade Openness on the Steady State Growth Rates of Selected Asian Countries with an Extended Exogenous Growth Model
- 22 T K Jayaraman and Jauhari Dahalan How Does Monetary Policy Transmission Mechanism Work in Samoa?
- 21 T K Jayaraman and Chee-Keong Choong More on "Shocking Aspects" of A Single Currency For Pacific Island Countries: A Revisit
- 20 Biman C Prasad Economic Integration and Labour Mobility: Are Australia and New Zealand Short-Changing Pacific Forum Island Countries?
- 19 T K Jayaraman and C K Choong Monetary Policy Transmission Mechanism In The Pacific Islands: Evidence From Fiji
18. K L Sharma High-Value Agricultural Products of The Fiji Islands: Performance, Constraints And Opportunities
- 17 Saten Kumar Income and Price Elasticities of Exports in Philippines
16. Saten Kumar Determinants of Real Private Consumption in Bangladesh
15. K.L Sharma Public Sector Downsizing in the Cook Islands: Some Experience and Lessons

14. Rup Singh and B C Prasad Do Small States Require Special Attention or Trade Openness Pays-off
13. Rup Singh Growth Trends and Development Issues in the Republic of Marshall Islands
12. B. Bhaskara Rao and G Rao Structural Breaks and Energy Efficiency in Fiji
11. Rup Singh Testing for Multiple Endogenous Breaks in the Long Run Money Demand Relation in India
10. B.B Rao, Rukimini Gounder and Josef Leoning The Level And Growth Effects in the Empirics of Economic Growth: Some Results With Data From Guatemala
9. B. Bhaskara Rao and K.L Sharma Testing the Permanent Income Hypothesis in the Developing and Developed Countries: A Comparison Between Fiji and Australia.
8. T. K Jayaraman and Chee K Choong Do Fiscal Deficits Cause Current Account Deficits In The Pacific Island Countries? A Case Study Of Fiji
7. Neelesh Gounder and Mahendra Reddy Determining the Quality of Life of Temporary Migrants using Ordered Probit Model.
6. T K Jayaraman Fiscal Performance and Adjustment in the Pacific Island Countries: A Review
5. Yenteshwar Ram and Biman C Prasad Assessing Fiji' Global Trade Potential Using the Gravity Model Approach
4. Sanjesh Kumar and Biman C Prasad Contributions of Exports of Services Towards Fiji's Output
3. Paresh Kumar Narayan, Seema Narayan, Biman Chand Prasad and Arti Prasad Tourism and Economic Growth: a Panel Data Analysis for Pacific Island Countries
2. T.K. Jayaraman and Chee-Keong Choong - Will External Borrowing Help Fiji's Growth.
1. Arti Prasad Paresh Kumar Narayan and Biman Chand Prasad- A Proposal for Personal Income Tax Reform For The Fiji Islands

2006/wp:

34. Paresh K Narayan and Arti Prasad - Modelling Fiji-US Exchange Rate Volatility.
33. T.K. Jayaraman and Chee-Keong Choong - Why is the Fiji Dollar Under Pressure?
32. T.K. Jayaraman and Baljeet Singh -Impact of Foreign Direct Investment on Employment in Pacific Island Countries: An Empirical Study of Fiji
31. B. Bhaskara Rao and Toani B Takirua - The Effects of Exports, Aid and Remittances on Output: The Case of Kiribati
30. B. Bhaskara Rao and Saten Kumar Cointegration, Structural Breaks and the Demand for Money in Bangladesh
29. Mahendra Reddy Productivity and Efficiency Analysis of Fiji's Sugar Industry
28. Mahendra Reddy Preferential Price and Trade Tied Aid: Implications on Price Stability, Certainty and Output Supply of Fiji's Sugarcane
27. Maheshwar Rao Challenges and Issues in Pro-Poor Tourism in South Pacific Island Countries: The Case of Fiji Islands
26. TK Jayaraman and Chee-Keong Choong Structural Breaks and the Demand for Money in Fiji

25. B. Bhaskara Rao and Saten Kumar Structural Breaks and the Demand for Money in Fiji
24. Mahendra Reddy Determinants of Public Support for Water Supply Reforms in a Small Developing Economy.
23. Mahendra Reddy Internal Migration in Fiji: Causes, Issues and Challenges
22. Mahendra Reddy and Bhuaneshwari Reddy Analyzing Wage Differential by Gender Using an Earnings Function Approach: Further Evidence from a Small Developing Economy.
21. Biman C. Prasad Trade: "WTO DOHA Round: An Opportunity or a Mirage for Fiji.
20. Benedict Y. Imbun Review of Labour Laws in Papua New Guinea
19. Benedict Y. Imbun Review of Labour Laws in Solomon Islands
18. Rup Singh Cointegration Tests on Trade Equation: Is Devaluation an Option for Fiji?
17. Ganesh Chand Employment Relations Bill: An Analysis.
16. TK Jayaraman and Chee-Keong Choong Public Debt and Economic Growth in the South Pacific Islands: A Case Study of Fiji
15. TK Jayaraman and Chee-Keong Choong Aid and Economic Growth in Pacific Islands: An Empirical Study of Aid Effectiveness in Fiji.
14. Rup Singh A Macroeconometric Model for Fiji.
13. Rup Singh and Saten Kumar Private Investment in Selected Asian Countries.
12. Ganesh Chand The Labour Market and Labour Market Laws in Fiji
11. Carmen V-Graf Analysis of Skilled Employment Demand and Opportunities in the Pacific Labour Market
10. Philip Szmedra, Kanhaiya L Sharma and Cathy L Rozmus Health Status, Health Perceptions and Health Risks Among Outpatients with Non-communicable Diseases in Three Developing Pacific Island Nations
9. Heather Booth, Guangyu Zhang, Maheshwar Rao, Fakavae Taomia and Ron Duncan Population Pressures in Papua New Guinea, the Pacific Island Economies, and Timor Leste
8. Mahendra Reddy Technical efficiency in Artisanal Fisheries: Evidence from a Developing Country.
7. Pares K Narayan and Biman C Prasad Macroeconomic Impact of the Informal Sector in Fiji
6. Biman C Prasad Resolving The Agricultural Land Lease Problem in The Fiji Islands; Current Discussions and The Way Forward.
5. Rup Singh & Saten Kumar Demand For Money in Developing Countries: Alternative Estimates and Policy Implications
 4. B. Bhaskara Rao, Rup Singh & Fozia Nisha, An Extension to the Neoclassical Growth Model to Estimate Growth and Level effects.
3. Rup Singh & Saten Kumar, Cointegration and Demand for Money in the Selected Pacific Island Countries.
2. B. Bhaskara Rao & Rup Singh, Estimating Export Equations.
1. Rup Singh, An Investment Equation for Fiji

2005/wp:

- 27 Neelesh Gounder & Biman C. Prasad & Biman C. Prasad What Does Affirmative Action Affirm: An Analysis of the Affirmative Action Programmes for Development in the Fiji Islands
- 26 B. Bhaskara Rao, Fozia Nisha & Biman C. Prasad The Effects of Life Expectancy on Growth
- 25 B. Bhaskara Rao, Rup Singh, & Neelesh Gounder, Investment Ratio in Growth Equations
- 24 T.K. Jayaraman, Regional Economic Integration in the Pacific: An Empirical Study

- 23 B. Bhaskara Rao & Maheshwar Rao, Determinants of Growth Rate: Some Methodological Issues with Time Series Data from Fiji
- 22 Sukhdev Shah, Exchange Rate Targeting of Monetary Policy
- 21 Paresh Narayan and Baljeet Singh, Modeling the Relationship between Defense Spending and Economic Growth for the Fiji Islands
- 20 TK Jayaraman, Macroeconomics Aspects of Resilience Building in Small States
- 19 TK Jayaraman, Some “Shocking Aspects” of a Regional Currency for the Pacific Islands.
- 18 Bimal B. Singh and Biman C. Prasad, Employment-Economic Growth Nexus and Poverty Reduction: An Empirical Study Based on the East Asia and the Pacific Region
- 17 Biman C. Prasad and Azmat Gani, Savings and Investment Links in Selected Pacific Island Countries
- 16 T.K. Jayaraman, Regional Integration in the Pacific.
- 15 B. Bhaskara Rao, Estimating Short and Long Run Relationships: A Guide to the Applied Economist.
- 14 Philip Szmedra, KL Sharma, and Cathy L. Rozmus, Managing Lifestyle Illnesses in Pacific Island States: The Case of Fiji, Nauru and Kiribati.
- 13 Philip Szmedra and KL Sharma, Lifestyle Diseases and Economic Development: The Case of Nauru and Kiribati
- 12 Neelesh Gounder, Rural Urban Migration in Fiji: Causes and Consequences
- 11 B. Bhaskara & Gyaneshwar Rao, Further Evidence on Asymmetric US Gasoline Price Responses
- 10 B. Bhaskara Rao & Rup Singh, Demand for Money for Fiji with PC GETS
- 9 B. Bhaskara Rao & Gyaneshwar Rao, Crude Oil and Gasoline Prices in Fiji: Is the Relationship Asymmetric?
- 8 Azmat Gani & Biman C. Prasad, Fiji’s Export and Comparative Advantage.
- 7 Biman C. Prasad & Paresh K Narayan, Contribution of the Rice Industry to Fiji’s Economy: Implication of a Plan to Increase Rice Production
- 6 Azmat Gani, Foreign Direct Investment and Privatization.
- 5 G. Rao, Fuel Pricing In Fiji.
- 4 K. Bunyaratavej & Tk Jayaraman, A Common Currency For The Pacific Region: A Feasibility Study.
- 3 Sukhdev Shah, Kiribati’s Development: Review And Outlook.

2 T.K. Jayaraman, B.D. Ward, Z.L. Xu, Ate the Pacific Islands Ready for a Currency Union? An Empirical Study of Degree of Economic Convergence

1 T.K. Jayaraman, Dollarisation Of The South Pacific Island Countries: Results Of A Preliminary Study

2004/wp:

15 Vincent D. Nomae, Andrew Manepora'a, Sunil Kumar & Biman C. Prasad, Poverty Amongst Minority Melanesians In Fiji: A Case Study Of Six Settlements In Suva

14 Elena Tapuaiga & Umesh Chand, Trade Liberalization: Prospects and Problems for Small Developing South Pacific Island Economies

13 Paresh K. Narayan, Seema Narayan & Biman C. Prasad, Forecasting Fiji's Exports and Imports, 2003-2020

12 Paresh K. Narayan & Biman C. Prasad, Economic Importance of the Sugar Industry in Fiji: Simulating the Impact of a 30 Percent Decline in Sugar Production..

11 B. Bhaskara Rao & Rup Singh, A Cointegration and Error Correction Approach to Demand for Money in Fiji: 1971-2002.

10 Khainhaiya L. Sharma, Growth, Inequality and Poverty in Fiji Islands: Institutional Constraints and Issues.

9 B. Bhaskara Rao, Testing Hall's Permanent Income Hypothesis for a Developing Country: The Case of Fiji.

8 Azmat Gani, Financial Factors and Investment: The Case of Emerging Market Economies.

7 B. Bhaskara Rao, The Relationship Between Growth and Investment.

6 Wadan Narsey, PICTA, PACER and EPAs: Where are we going? Tales of FAGS, BOOZE and RUGBY

5 Paresh K. Narayan & Biman C. Prasad, Forecasting Fiji's Gross Domestic Product, 2002-2010.

4 Michael Luzius, Fiji's Furniture and Joinery Industry: A Case Study.

3 B. Bhaskara Rao & Rup Singh, A Consumption Function for Fiji.

2 Ashok Parikh & B. Bhaskara Rao, Do Fiscal Deficits Influence Current Accounts? A Case Study of India.

1 Paresh K. Narayan & Biman C. Prasad, The Casual Nexus Between GDP, Democracy and Labour Force in Fiji: A Bootstrap Approach.

2003/wp:

11 B. Bhaskara Rao & Rup Singh, Demand For Money in India: 1953-2002.

10 Biman C. Prasad & Paresh K. Narayan, Fiji Sugar Corporation's Profitability and Sugar Cane Production: An Econometric Investigation, 1972-2000.

9 B. Bhaskara Rao, The Nature of The ADAS Model Based on the ISLM Model.

- 8 Azmat Gani, High Technology Exports and Growth – Evidence from Technological Leader and Potential Leader Category of Countries.
- 7 TK Jayaraman & BD Ward, Efficiency of Investment in Fiji: Results of an Empirical Study.
- 6 Ravinder Batta, Measuring Economic Impacts of Nature Tourism.
- 5 Ravinder Batta, Ecotourism and Sustainability.
- 4 TK Jayaraman & Rajesh Sharma, Determinants of Interest Rate Spread in the Pacific Island Countries: Some Evidence From Fiji.
- 3 T.K. Jayaraman & B.D. Ward, Is Money Multiplier Relevant in a Small, Open Economy? Empirical Evidence from Fiji.
- 2 Jon Fraenkel, The Coming Anarchy in Oceania? A Critique of the 'Africanisation' of the South Pacific Thesis.
- 1 T.K. Jayaraman, A Single Currency for the South Pacific Islands: A Dream or A Distant Possibility?