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Structural Breaks and the Demand for Money in Fiji¹

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Abstract

This paper fills a gap in the empirical work on the demand for money for Fiji. We allowed for structural breaks in the cointegrating equation, within the Gregory and Hansen framework, and found that there is a cointegrating relationship between real narrow money, real income and the nominal rate of interest in all the three types of their models. However, only the model with an intercept shift for the 1987 political coup yields a meaningful cointegrating relationship. We tested for its temporal stability and found that the demand for money in Fiji is stable.

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1. Introduction

A countless number of empirical studies have estimated the demand for money in many countries and examined its stability. Demand for money and, more importantly, its temporal stability have important implications for the selection of the monetary policy instruments. In a classic paper Poole (1970) has shown that when the LM curve is unstable, central banks should use the bank rate as the instrument of monetary policy, but when the IS curve is unstable the appropriate monetary policy instrument is money supply. Since a major source of instability in LM is due to instability in the demand for money, the stability of the demand for money is important.

In the developed countries the demand for money is found to be temporally unstable, since the late 1980s, due to the liberalization of the financial markets. Therefore, central banks in the developed countries have switched to bank rate as their main instrument of monetary policy. In contrast there is no significant evidence that the demand for money in the developing countries has also become unstable; see a recent comprehensive study by Oskooee-Bahmani and Rehman (2005). Nevertheless, central banks in many developing countries, including Fiji, have also switched to the bank rate as their instrument of monetary policy. Such an inappropriate choice of monetary policy instrument could actually lead to increased instability and it is important to test the stability of the demand for money with some recent developments in time series techniques.

The main purpose of this paper is to fill a gap in the existing empirical work on the stability of the demand for money in the developing countries by allowing for structural breaks in the cointegrating relationship. To limit the scope of this paper, we examine the stability of demand for money only in Fiji with the Gregory and Hansen (1996a) technique. Needless to say our methodology can be easily used to analyse the stability of demand for money (or any other cointegrating relationship) in other countries. The outline of this paper is as follows. Section 2 briefly reviews the Gregory and Hansen

model for estimating cointegrating equations with structural breaks. Section 3 presents empirical results for Fiji and discusses their implications. Summary and conclusions are in Section 4.

2. The Gregory-Hansen Equations

Gregory and Hansen (1996a) have proposed residual based tests for the null of no cointegration with structural breaks against the alternative of cointegration. In Gregory and Hansen (1996a) there are three models with alternative assumptions about structural breaks namely (1) level shift; (2) level shift with trend and (3) regime shift where both the intercept and the slope coefficients change. The single break date in these models is endogenously determined. These three models can be stated with the following simple specifications with two variables.⁴

$$Y_t = \mathbf{m}_1 + \mathbf{m}_2 \mathbf{j}_{tk} + \mathbf{a}_1 X_t + \mathbf{e}_t \quad (1)$$

$$Y_t = \mathbf{m}_1 + \mathbf{m}_2 \mathbf{j}_{tk} + \mathbf{b}_1 t + \mathbf{a}_1 X_t + \mathbf{e}_t \quad (2)$$

$$Y_t = \mathbf{m}_1 + \mathbf{m}_2 \mathbf{j}_{tk} + \mathbf{b}_1 t + \mathbf{a}_1 X_t + \mathbf{a}_2 X_t \mathbf{j}_{tk} + \mathbf{e}_t \quad (3)$$

where Y is the dependent and X is the independent variable, t is time subscript, \mathbf{e} is an error term, k is the break date and \mathbf{j} is a dummy variable such that

$$\mathbf{j}_{tk} = \begin{cases} 0 & \text{if } t \leq k \\ 1 & \text{if } t > k \end{cases} \quad (4)$$

It is easy to extend these models for more than one explanatory variable.

⁴ A fourth model developed by Gregory and Hansen (1996b) is

$$Y_t = \mathbf{m}_1 + \mathbf{m}_2 \mathbf{j}_{tk} + \mathbf{b}_1 t + \mathbf{b}_2 \mathbf{j}_{tk} + \mathbf{a}_1 X_t + \mathbf{a}_2 X_t \mathbf{j}_{tk} + \mathbf{e}_t$$

We ignore this model in this paper because of some limitations in our software.

A limited number of previous studies on the demand for money in Fiji are Lockett (1987), Joyson (1997), Jayaraman and Ward (2000), Katafono (2001), Rao and Singh (2005a) and more recently Singh and Kumar (2006a and 2006b). The merits and weaknesses of these earlier studies were discussed in Rao and Singh (2005a). While Katafono found that the demand for money is unstable, Rao and Singh, Jayaraman and Ward and Singh and Kumar found that the demand for money in Fiji is well determined and temporally stable. In all these previous studies an important issue that was not addressed is that the cointegration relationship may have a structural break during the sample period. Rao and Singh only briefly discuss this issue. Therefore, we explore the stability of the demand for money with the Gregory-Hansen techniques. Since Rao and Singh have obtained similar coefficients for their cointegrating equations with two alternative techniques namely the LSE-Hendry GETS and the Johansen maximum likelihood systems methods, we shall use their specification which is:

$$\ln M_t = \mathbf{m} + \mathbf{a}_1 \ln Y_t - \mathbf{a}_2 r_t + \mathbf{e}_t \quad (5)$$

where M is real narrow money, Y is real GDP and r is the nominal rate of interest. The implied specifications for the three Gregory and Hansen equations with structural breaks are as follows.

$$\ln M_t = \mathbf{m} + \mathbf{m} \mathbf{j}_{tk} + \mathbf{a}_1 \ln Y_t - \mathbf{a}_2 r_t + \mathbf{e}_t \quad (6)$$

$$\ln M_t = \mathbf{m} + \mathbf{m} \mathbf{j}_{tk} + \mathbf{b}_1 t + \mathbf{a}_1 \ln Y_t - \mathbf{a}_2 r_t + \mathbf{e}_t \quad (7)$$

$$\ln M_t = \mathbf{m} + \mathbf{m} \mathbf{j}_{tk} + \mathbf{b}_1 t + \mathbf{a}_1 \ln Y + \mathbf{a}_{11} \ln Y \mathbf{j}_{tk} - \mathbf{a}_2 r_t - \mathbf{a}_{22} r_t \mathbf{j}_{tk} + \mathbf{e}_t \quad (8)$$

For convenience these equations will be referred as GH-I, GH-II and GH-III respectively.

The Gregory-Hansen method is essentially an extension of similar tests for unit root tests with structural breaks, for example, by Zivot and Andrews (1992). The break date is searched by estimating the cointegration equations for all possible break dates in the sample and then selecting a date where the test statistic is the minimum (i.e., where the

absolute value of the ADF test statistic is the maximum). However, the critical values for cointegration in this method are different. With regime shifts the distribution theory to evaluate the residual based tests is not the same as the standard MacKinnon (1991) cointegration tests used in the Engle-Granger two-step procedure. Therefore, Gregory and Hansen have tabulated the critical values by modifying the MacKinnon (1991) procedure for testing cointegration in the Engle-Granger method with unknown breaks. We follow this methodology in this paper.

3. Empirical Estimates of the Break Date

The definitions of variables and sources of data are same as in Rao and Singh (2005a). Our sample period is from 1971 to 2002 but due the presence of some lagged variables, the three models in equations (6) to (8) are estimated from 1974 to 2002 and the results are given below in Table-1.

Table-1
Tests for Cointegration
with Structural Breaks
1974-2002

	Brake Date	GH Test Statistic	5% Critical Value	Reject H ₀ of no Cointegration
GH-I	1987	-5.19111	-4.92	YES
GH-II	1976	-5.95961	-5.29	YES
GH-III	1987	-6.71172	-5.50	YES

These results, which are self-explanatory, imply that irrespective of which of the three models with structural breaks is used, there is a cointegrating relation between real money, real income and the nominal rate of interest in Fiji. However, the endogenously determined brake date is 1987 in GH-I and GH-III, but different at 1976 in GH-II. Since the null is rejected by all the three models, it hard to decide which is the best. Therefore, we have estimated the cointegrating equations for the three models with the Engle-Granger method and the first stage OLS equations are given below in Table-2.

From these estimates it can be said that GH-I is the most plausible model. In this model all the estimated coefficients, except the pre 1987 intercept, are significant and their values are plausible although the estimate of income elasticity at 0.76 seems be a bit low. However, the Wald test could not reject the null that that it is unity at the 5% level. The computed test statistic, with its p-value in brackets, is 1.462 (0.227).

In GH-II the estimate of income elasticity is low at 0.262 and insignificant. In GH-III income elasticity, after the break, is very high at almost three and the estimates of the two interest rate coefficients are insignificant. These results in GH-II and GH-III can be rejected as implausible because statistical techniques, as noted by Smith (2000) and Rao (2006), are merely tools to summarize facts and are not appropriate to answer questions

that belong to economic theory.⁵ Therefore, we shall use the residuals from GH-I to estimate the short run dynamic equation for the demand for money with the error-correction adjustment model (ECM).

Table-2
Cointegrating Equations 1974-2002⁶

	GH-I	GH-II	GH-III
Intercept	0.112 (0.07)	3.736 (0.98)	10.340 (5.71)*
Trend		0.024 (2.91)*	
$\ln Y_t$	0.758 (3.80)*	0.262 (0.51)	-0.625 (2.50)*
r_t	-0.035 (4.49)*	-0.029 (2.78)*	-0.003 (0.20)
Dummy 1976		-0.197 (2.26)*	
Dummy 1987	0.230 (4.37)*		-22.248 (3.68)*
Dummy 1987 $\times \ln Y_t$			2.912 (3.82)*
Dummy 1987 $\times r_t$			0.027 (0.83)

⁵ Smith (2000) distinguishes between three stages in applied economic work namely purpose (or objective), summary of facts and interpretation of facts. Within this threefold classification, statistical techniques are seen as tools to develop credible summaries of the observed facts. Purpose and interpretation are left to the analyst according to his/her preferred economic theories. Therefore, in evaluating the relative merits of the alternative statistical estimates, it is important to ask: how good a particular result is for summarizing the observed facts; see also Rao (2006).

⁶ Absolute t-ratios are reported below the coefficients. * indicates significance at 5% level.

In developing an appropriate ECM model for the short run, we adopted the LSE-Hendry's GETS approach in the second stage. This second stage equation is estimated with OLS in which $\Delta \ln M_t$ is regressed on its lagged values, the current and lagged values of $\Delta \ln Y_t$ and Δr_t and the one period lagged residuals from the cointegrating vector of Gregory Hansen i.e., from equation GH-I. We have used lags up to 4 periods and using the variable deletion tests in Microfit 4.1 and arrived at the following parsimonious equation:

$$\begin{aligned} \Delta \ln M_t = & -0.392 ECM_{t-1} + 1.092 \Delta \ln Y_t - 0.816 \Delta \ln Y_{t-1} \\ & (1.80)** \quad (2.55)* \quad (1.84)** \\ & + 0.027 \Delta^2 r_{t-1} \\ & (2.45)* \end{aligned} \quad (9)$$

$$\begin{aligned} \bar{R}^2 = 0.532, \quad SER = 0.098, \quad Period: 1975-2002 \\ X^2_{sc1} = 0.691 (0.41), \quad X^2_{ff} = 4.088 (0.04)*, \\ X^2_n = 0.791 (0.67), \quad X^2_{hs} = 3.710 (0.05)* \end{aligned}$$

where * and ** indicate significance at the 5% and 10% levels respectively. It may be noted from these estimates that it is possible to reduce further the number of estimated coefficients to increase the degrees of freedom. The coefficients of $\Delta \ln Y_t$ and $\Delta \ln Y_{t-1}$ are close and opposite in sign. When this restriction is tested, the Wald test computed $\chi^2(1)$ test statistic with p value in the parenthesis is 0.157 (0.692) is insignificant and the constraint could not be rejected. The following ultra parsimonious equation is based on this restriction:

$$\begin{aligned} \Delta \ln M_t = & -0.391 ECM_{t-1} + 0.958 \Delta^2 \ln Y_{t-1} \\ & (1.83)** \quad (3.69)* \\ & + 0.026 \Delta^2 r_{t-1} \\ & (2.46)* \end{aligned} \quad (10)$$

$$\begin{aligned} \bar{R}^2 = 0.548, \quad SER = 0.097, \quad Period: 1975-2002 \\ X^2_{sc1} = 0.749 (0.39), \quad X^2_{ff} = 3.951 (0.05)*, \\ X^2_n = 1.039 (0.60), \quad X^2_{hs} = 2.490 (0.12) \end{aligned}$$

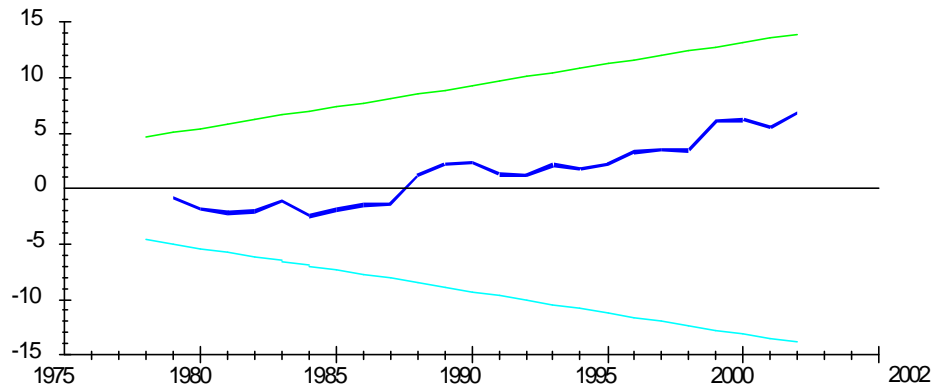
The summary statistics of this equation have marginally improved. All the estimated coefficients are significant. The coefficient of the lagged error correction term is significant at 10% level with correct negative sign, and serves as the expected negative

feedback function. This implies that if there are departures from equilibrium in the previous period, this departure is reduced by about 40% in the current period. The χ^2 statistics indicate that there is no serial correlation (χ^2_{sc1}), non-normality (χ^2_n) and heteroscedasticity (χ^2_{hs}) in the residuals. However, it may be noted that the functional form misspecification χ^2_{ff} test is marginally significant at the 5% but not at 1% level. This is not unusual for dynamic equations because it is hard to claim that the complex nature of dynamic adjustments, with limited data, can be adequately captured with linear specifications.

Having obtained the long run equilibrium estimates and the dynamic counterpart, it is important to test for the stability of the money demand function. When we subjected our preferred equation (10) to CUSUM and CUSUMSQ stability tests, neither the CUSUM nor the CUSUM SQUARES showed any instability. The plots of these tests are given in Figure 1 and 2 below. They show that the money demand function is temporally stable in Fiji. Therefore, following Poole (1970) it can be said that money supply is the appropriate monetary policy instrument for the Reserve Bank of Fiji (RBF). However, if the RBF follows the advanced countries and target the rate of interest, this would probably cause more instability in GDP. In this respect our findings are consistent with those in Rao and Singh (2005a), Singh and Kumar (2006) and Jayaraman and Ward (2000) although these works did not allow for structural breaks in their cointegration equations.

Figure 1: CUSUM TEST FOR EQUATION 10

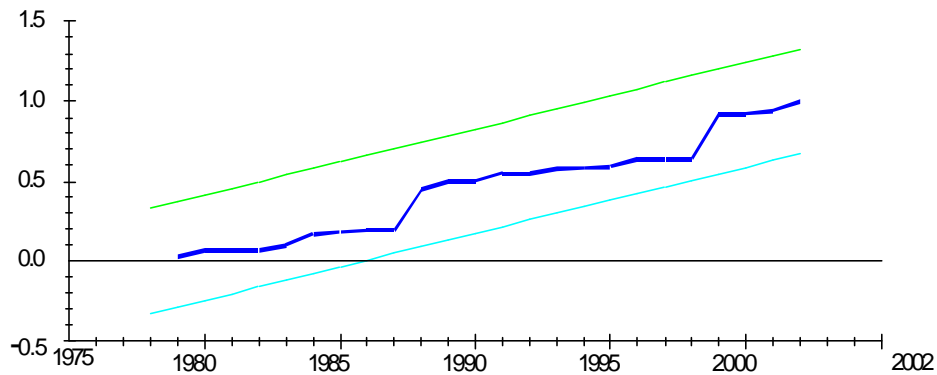
Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure 2: CUSUM SQUARES TEST FOR EQUATION 10

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

4. Conclusion

In this paper, we have used the Gregory Hansen procedure to test the stability of the demand for money in Fiji. We believe that our study is perhaps the first attempt to estimate and test the demand for money in Fiji with structural breaks. Our estimates imply that there exist a cointegrating relationship between real money, real income and nominal rate of interest which might have shifted up by about 0.23 after the 1987 coup. This may be due to some increased precautionary demand for liquidity. However, the major finding of this paper is that there is a well-determined and stable demand for money in Fiji from 1971 to 2002.

Our estimates imply that the income elasticity of 0.758 is, although somewhat lower than in the earlier studies of unity, the Wald test indicates that our estimate is not significantly different from unity. The estimate of interest rate elasticity, at its mean value of 6.97, is about -0.244 and consistent with the previous findings. We hope that our paper will encourage further applied work with structural breaks on the demand for money in other countries as well as on other relationships.

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