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Testing for Nonlinearities in the Adjustments of Commercial Banks' Retail Rates to Interbank Rates: The Case of Mauritius

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Work in progress

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Abstract

This paper investigates the rigidity in commercial banks' interest rates for the case of Mauritius using a non-linear framework. The long-run cointegrating relationships between each of banks' retail rates (i.e., deposit and lending rates) and interbank rates are examined using threshold models designed to study non-linear adjustments. From the momentum autoregressive model (MTAR), we find that discrepancies between the lending rate and the interbank rate from their long-run equilibrium level are eliminated rapidly when there negative shocks to the margin while others are allowed to persist. This indicates that discrepancies exhibit more momentum when they are declining than when they are increasing. In other words, whether interbank rate is increasing or decreasing, lending rates are adjusted more rapidly for decreases in the margin but they are allowed to persist for increases in the margin.

Keywords*: Interest rates; Asymmetric adjustment; Threshold autoregressive process*

JEL classification: E43, C50

1. Introduction

Interest rate liberalisation strategy in developing countries is based on the premise that administered interest rates (retail lending and deposit rates) set below their market clearing levels result in misallocation of financial resources and adversely affect investment and economic growth (McKinnon, 1973; Shaw, 1973; Fry, 1994). The usual policy prescription in the development literature is therefore to allow commercial banks to determine their own interest rates and these retail interest rates will be market clearing. Moreover, with interest rate liberalisation, a central tenet of monetary policy is the use of money market rate to prompt changes in lending rates to different sectors and borrowers, which in turn would influence spending behaviour of economic agents. This is based on the implicit assumption that banks behave symmetrically and also pass on any changes in the base rate to their customers instantaneously. However, this issue whether banks would respond symmetrically with their retail rates market-clearing following liberalisation has been questioned on many grounds. Firstly, there is evidence of sluggish retail rate adjustment by commercial banks leading to inefficient credit allocation even after liberalisation. Secondly, there is a growing literature on financial market imperfections (Stiglitz, 1994), in particular, the presence of asymmetric information in credit markets inhibiting commercial banks from raising lending rates to their market clearing level (Stiglitz and Weiss, 1981). There is also a wide range of literature on market structure which explains the rigidity of interest rates (Flannery, 1982; Hannan and Berger, 1991; Cottarelli and Kourelis, 1994 amongst others). According to these authors, rigidities are observed because of the adjustment costs associated with the repricing of deposits and loans, and informing customers. It is also found that the greater the monopolistic power that is wielded by banks and the more intense the conjectural interdependence among them, the greater is the rigidity of the retail rates. Such hypothesised asymmetric behaviour in deposit and lending rates, resulting from monopolistic power, has been tested empirically by Neumark and Sharpe (1992) and Scholnick (1996), amongst others.

An important development in the recent time series literature is the examination of non-linear adjustment mechanisms. Much of the motivation stems from a wide number of studies showing that key macroeconomic variables such as real GDP, unemployment, investment and productivity display asymmetric behaviour over the course of the business cycle (Granger and Lee, 1989; Teräsvirta and Anderson, 1992; Sichel, 1993; Beaudry and Koop, 1993; Potter, 1995). This framework has also been used by a few to study the behaviour of the term structure of interest rates (Balke and Fomby, 1997; Anderson, 1997; Enders and Granger, 1998) while others have examined the asymmetric responses to changes in monetary policy (Shen, 2000; Lim, 2001).

In Mauritius, commercial banks' interest rates have been quite inflexible characterised by high margins in the post-liberalisation period (Jankee, 1999; IMF/World bank 2003). It will thus be instructive to examine any such rigidity in the commercial banks' retail interest rates following changes in the monetary policy stance. In particular, this paper investigates the response of commercial banks' deposit and lending rates following a change in the interbank rate which the Bank of Mauritius (Central bank) influences indirectly through its daily open market operations. This work will also provide some insights on the nature of the banking sector in Mauritius in relation to interest rate determination. The study exploits the Enders and Granger (1998) framework, which examined cointegration with asymmetric error-correction, and which was further developed by Enders and Siklos (2001) in the multivariate context. The paper is organised as follows: Section 2 discusses some competing theories of asymmetric adjustment in interest rates. Section 3 provides for a brief overview of the developments in the Mauritian banking sector. Section 4 describes the non-linear framework used in this study. Section 5 contains the empirical analysis and Section 6 summarises the main findings and offers some avenues for further work.

2. Asymmetric Transmission of Wholesale Interest Rate to Retail Interest Rates

The concept of asymmetry implies that the costs of adjusting to a higher target level are not necessarily equivalent to the costs of adjusting to a lower target level. Banks in concentrated markets are found to be slower in raising interest rates on deposits in response to a rise in the wholesale interest rate but faster in reducing them in response to a decline in the wholesale interest rate. Conversely, in the loan market, lending rates tend to be adjusted upward relatively faster following a rise in the wholesale interest rate as compared to a downward revision when the wholesale interest rate declines. Thus, a greater rigidity is observed in deposit rate increases and lending rate decreases because banks expect high costs from the breakdown of collusive arrangements if they try to raise their deposit rates or lower their lending rates while banks are quicker to lower their deposit rates or raise their lending rates following changes in the official rate in order to maintain their market share without facing any fears of persecution by other banks. On the other hand, Hannan and Berger (1991) suggested that firms in more concentrated markets may also find deposit rates more rigid when the stimulus for a deposit rate change is downward. More precisely, they argued that the fear of an adverse reaction from depositors following a fall in deposit rates can lead to a slower adjustment when deposit rates are falling than when deposit rates are rising. They categorised these two distinct types of behaviour as “collusive arrangement” and “customer reaction”.

Neumark and Sharpe (1992) found evidence of asymmetric impacts of market concentration on the dynamic adjustment of interest rates to shocks in the U.S. Their study showed that banks in concentrated markets are slower to raise interest rates on deposits in response to rising market interest rates but faster to reduce them in response to declining market interest rates. They argued that since the deposit interest rate is inversely related to price charged to banks for deposits, their results supported the traditional view that market concentration leads to downward price rigidity and upward price flexibility. Using an asymmetric error correction technique, Scholnick (1996) examined the rigidity of interest rates in Singapore and Malaysia. He found that the mean adjustment lag of the Malaysian deposit rate is shorter when it is above its equilibrium than when it is below, implying that banks tend to adjust their deposit rates downward more rapidly than upward. However, he could not draw similar conclusions for lending rates in Malaysia given that they were determined by monetary authorities. As for Singapore he found no evidence of asymmetry in either deposit or lending rates. Moazzami (1999) examined the extent of lending rate stickiness in Canada and the US using the error-correction framework. The movement towards fewer, larger banks with lower adjustment costs coupled with relaxed restrictions on banks branching led to a gradual decline in the lending rate stickiness over time in the U.S. In comparison, lending rates were less rigid in Canada where a highly competitive market structure was maintained throughout the 1970s and 1980s. However, financial system deregulation in the late 1980s resulted in an oligopolistic market structure causing the lending rates to become stickier.

Lim (2001) studied the asymmetric adjustments between three Australian interest rates using a multivariate error-correction model. He found that interest rate adjustments are asymmetric in the short-run but not in the long-run. In particular, his results suggested that banks adjust retail interest rates in response to a change in the wholesale interest rate at a faster rate during periods of monetary easing than during periods of monetary tightening. Heffernan (1997) examined the dynamics of British retail deposit and lending rates to changes in the base rate using an error correction model. He found that the retail banking market exhibits features of imperfect competition and the adjustment differences for different saving products can affect the speed of the money transmission mechanism. Jha (2002) discussed the reasons for the downward rigidity of Indian interest rates. He highlighted the role of three factors namely the overhang of non-performing assets, high public debt and the structure of the debt, and the policy pursued with respect to accumulation of foreign exchange reserves.

3. Banking Sector Policies

In this section, we highlight the major changes in the banking sector policies since the early 1970s with emphasis on interest rate policies. Financial reforms have been instituted since the late seventies not only to enhance competition in the banking sector but to also diversify the financial system. The Mauritian financial system has so far remained highly dominated by the banking sector despite the wide range of policies implemented over the preceding decades. The structure of the banking industry seems to be characterised by a lack of competition since more than seventy per cent of the total banking assets is owned by the two largest banks (IMF/World Bank Report, 2003). In addition to banking sector policies, a number of innovations have taken place in the banking sector especially in the 1990s in relation to product range and scope of operations, use of technology, portfolio management and diversification. Overall, the banking sector has invariably been subjected to a wide range of financial repressionist measures until the early 1990s. Table 1 indicates the main financial reforms undertaken in the economy.

The first set of control has been the regulation of banks' interest rates by monetary authorities throughout the 1970s until late 1980s. Other repressionist policies consisted of the imposition of cash ratio and liquid asset ratio that were gradually increased over the years as well as the exchange control on current and capital transactions. In the mid 1970s, the monetary authorities tightened their control over the financial system in an attempt to regulate credit expansion and allocate it to productive sectors. In the early 1980s, the control over the overall credit was modified whereby sectors were categorised into priority and non-priority and ceilings were imposed respectively on both types of sectors. Furthermore, banks were individually subject to a certain quantum of credit depending upon their extent of deposit mobilisation and credit creation. The early 1980s were marked by the beginning of the progressive liberalisation of the financial system. Controls over interest rates were gradually lifted. Exchange control on current transactions was no longer imposed as from mid 1980s. By late 1980s, interest rates were fully liberalised. However, quantitative controls in the form of reserve requirements and credit ceilings continued to be imposed. The 1990s were marked by the relaxation of most of the remaining banking sector controls. Credit ceilings were gradually abolished and the exchange control act was suspended by mid 1990s. The cash ratio and liquid asset ratio were gradually lowered and the liquid asset ratio was brought down to zero in 1997.

Table 1: Sequencing of Financial Sector Reforms

July 1988	Liberalisation of interest rates
July 1991	Issue of Bank of Mauritius bills
November1991	Auctioning of bills
July 1992	Abolition of ceilings on credit to priority sectors
July 1993	Abolition of credit ceilings on non-priority sectors Imposition of a credit-deposit ratio Minimum risk-weighted capital adequacy ratio of 8%
February 1994	Setting up of the Secondary Market Cell at Bank of Mauritius
June 1994	Bank Rate linked with weighted average yield of Treasury Bill over preceding 12 weeks plus a margin
July 1994	Suspension of Exchange Control Act Establishment of the Interbank Foreign Exchange Market
July 1995	Bank rate linked to overall yield on Treasury bills at most recent auction plus a margin

July 1996	Abolition of credit-deposit ratio Imposition of 15% limit on the overall foreign exchange exposure
December 1996	Bank rate linked to overall yield on Treasury bills at most recent auction plus a margin
July 1997	Cash ratio brought down to 6% and non-cash liquid asset ratio to 0%
July 1998	Issue of 728-day Treasury bills
December 1998	Over the Counter (OTC) sales to individuals and non-financial Institutions.
December 1999	Issue of 30-day Treasury bills Introduction of Reversed REPO Transactions Introduction of Lombard facility
November 2000	Introduction of Swap Transactions
December 2000	Introduction of the Mauritius Automated Clearing and Settlement System
February 2002	Introduction of primary dealer system

Source: Bank of Mauritius

The financial liberalisation programme was also accompanied by other market-oriented reforms such as a free float exchange rate, the auctioning of Treasury bills, the setting up of a secondary market for government securities and adoption of market-based system of monetary policy implementation. In addition, bank branches expansion has also contributed largely to the institutional development of the banking sector. From 32 in the 1970, the number of bank branches expanded significantly to reach 117 in 1990 and 145 as at June 2003. During recent years, there has been substantial investment in financial infrastructure by banks providing card-based payment services such as credit and debit cards, and direct debits. Other facilities like phone banking, home banking, internet banking and Pc banking are also provided by some banks (see Annual reports, Bank of Mauritius).

4. Non-linear Framework

Standard models of cointegration assume linearity and symmetric adjustment. For instance if two variables x_{1t} and x_{2t} are integrated of order 1, then the Engle and Granger (1987) two-step test for cointegration involves an OLS estimation of the long-run relationship in the first stage given by,

$$x_{1t} = b_0 + b_1 x_{2t} + m_t \quad (1)$$

where b_0 and b_1 are the estimated parameters and m_t is the disturbance term. In the second stage, the estimated disturbance terms m_t's are used to estimate r in the following regression:

$$\Delta\hat{m}_t = r\hat{m}_{t-1} + e_t \quad (2)$$

where e_t is a white-noise process. The estimated value of r allows us to test the cointegration relationship between x_{1t} and x_{2t}. A sufficient condition for the stationarity of $\hat{m}_t$ is that $-2 < r < 0$. Therefore, rejecting the null of no cointegration implies that the residuals in (1) are stationary with mean 0. According to Engle-Granger (1987) theorem, if $r \neq 0$, (1) and (2) jointly imply the existence of an error-correction representation of the variables. This can also be extended to a multivariate case such that the error-correction model can be represented as,

$$\Delta x_{1t} = a_i(x_{1,t-1} - b_0 - b_1 x_{2,t-1} + \ldots . b_n x_{n,t-1}) + \sum_{j=1}^{k} b_{1j}\Delta x_{1,t-j} + \sum_{j=0}^{k} b_{2j}\Delta x_{2,t-j} + \ldots\ldots \sum_{j=0}^{k} b_{nj}\Delta x_{n,t-j} + u_{1t} \quad (3)$$

where u_{1t} is a white noise disturbance term and k is the lag length. The term inside the brackets provide the error correction mechanism. Alternately, Johansen's (1986) procedure can be used which entails the estimation of the following relationship,

$$\Delta x_t = p x_{t-1} + v_t \quad (4)$$

where x_t is a vector of I(1) variables, p is an $n \times n$ matrix and v_t is a vector of normally distributed disturbances. The Johansen's approach involves the estimation of p and determining its rank. The implicit assumption in this test is that if the rank (p) is not equal to zero, the system exhibits symmetric adjustment around $x_t = 0$ in that for any $x_t \neq 0$, Δx_{t+1} always equals $p\, x_t$.

Enders and Granger (1998) argued that the cointegration tests from the Engle and Granger (1987) and the Johansen (1988) frameworks are misspecified if adjustment is asymmetric. In the context of interest rates analysis, the implicit assumption is that the interest rate responses are symmetric in the sense that a shock to the wholesale interest rate of a given magnitude will lead to the same response in retail rates, regardless of whether the shock reflects a rise or a decline in wholesale interest rate. The authors also found that the Augmented Dickey-Fuller test for the presence of unit roots is not powerful enough to test the null hypothesis of a unit root test in the residuals against the alternative hypothesis of stationarity more particularly in a multi-threshold model.

Enders and Granger (1998) considered an alternative error correction specification called threshold autoregressive (TAR) model in which equation (2) is represented as,

$$\Delta\hat{m}_t = \begin{cases} r_1\hat{m}_{t-1} + e_t & \text{if} \quad \hat{m}_{t-1} < t \\ r_2\hat{m}_{t-1} + e_t & \text{if} \quad \hat{m}_{t-1} \geq t \end{cases} \qquad (5)$$

where t is the value of the critical threshold. Once again, the sufficient condition for the stationarity of $\hat{m}_t$ is $-2 < r_1, r_2 < 0$. The adjustment process is then quantified as,

$$\Delta\hat{m}_t = I_t r_1\hat{m}_{t-1} + (1 - I_t) r_2\hat{m}_{t-1} + e_t \qquad (6)$$

Where I_t is known as the Heaviside indicator function such that,

$$I_t = \begin{cases} 1 & \text{if} \quad \hat{m}_{t-1} < t \\ 0 & \text{if} \quad \hat{m}_{t-1} \geq t \end{cases} \qquad (7)$$

Usually t is set to zero in economic applications. Assuming the system is convergent $\hat{m}_t = 0$ is considered as the long-run equilibrium value of the sequence. If $\hat{m}_{t-1}$ is below its long-run equilibrium value, the adjustment is $r_1\hat{m}_{t-1}$ and if $\hat{m}_{t-1}$ is above its long-run equilibrium, the adjustment is $r_2\hat{m}_{t-1}$. The equilibrium error therefore behaves like a threshold autoregression.

Given that adjustment is symmetric when $r_1 = r_2$, the Engle-Granger test given by (2) becomes a special case of (6) and (7). The error-correction representation can now be written as:

$$\Delta x_{1t} = l_1 I_t \hat{m}_{t-1} + l_2 (1 - I_t)\hat{m}_{t-1} + \sum_{j=1}^{k} b_{1j}\Delta x_{1,t-j} + \sum_{j=0}^{k} b_{2j}\Delta x_{2,t-j} + \ldots\ldots \sum_{j=0}^{k} b_{nj}\Delta x_{n,t-j} + u_{1t} \qquad (8)$$

where l_1 and l_2 are the speed of adjustment coefficients for negative and positive discrepancies respectively and I_t is the Heaviside indicator specified in accordance to (7).

Enders and Granger (1998) suggested that TAR models could adequately capture aspects of "deep" movements in series. For instance, if $|l_1| < |l_2|$ then the negative phase of the $\{m_{t-1}\}$ sequence will tend to be more persistent than the positive phase. The authors showed that (6) could be augmented with lagged changes in the $\{\hat{m}_t\}$ sequence such that it becomes a p^{th} order process given as:

$$\Delta \hat{m}_t = I_t r_1 \hat{m}_{t-1} + (1 - I_t) r_2 \hat{m}_{t-1} + \sum_{i=1}^{p-1} g_i \Delta \hat{m}_{t-i} + e_t \qquad (9)$$

Diagnostic tests on the residuals and various model selection criteria are used to determine the appropriate lag length.

Enders and Granger (1998) suggested that sometimes when adjustment is asymmetric, some series exhibit more 'momentum' in one direction than the other. They suggested an alternative specification such that the threshold depends on the previous period's change in $\hat{m}_{t-1}$. Here the Heaviside indicator is set according to,

$$I_t = \begin{cases} 1 & \text{if } \Delta \hat{m}_{t-1} < t \\ 0 & \text{if } \Delta \hat{m}_{t-1} \geq t \end{cases} \qquad (10)$$

Models constructed using this specification are called Momentum Threshold Autoregressive (M-TAR) models in that the $\{\hat{m}_t\}$ sequence exhibits more "momentum" in one direction than the other and such models can therefore capture "steep" movements in series. Thus, if $|l_1| < |l_2|$, the M-TAR model exhibits relatively less decay for negative values of $\Delta\hat{m}_{t-1}$ than for positive values.

5. Sources of Data and Cointegration Tests

The data used in this analysis consists of quarterly series on interbank money market (IBR) to represent the wholesale rate, and commercial banks' deposit and lending rates for the retail rates. Thereafter, IBR is referred to as the interbank rate. The observations run from September 1988 to September 2003, which represents the post-liberalisation period given that interest rates were fully liberalised by September 1988. The deposit rate (DEPR) is commercial banks' interest rates on 3-month deposits and the lending rate (LENR) is the rate of interest charged by banks on housing loans. All three series are obtained from the annual reports of the Bank of Mauritius. We first check the order of integration of the three interest rates using the Augmented Dickey-Fuller (ADF) test. The test statistics are given in Table 1 along with the corresponding critical values. All three series are found to be integrated of order 1. This justifies the subsequent test of cointegration.

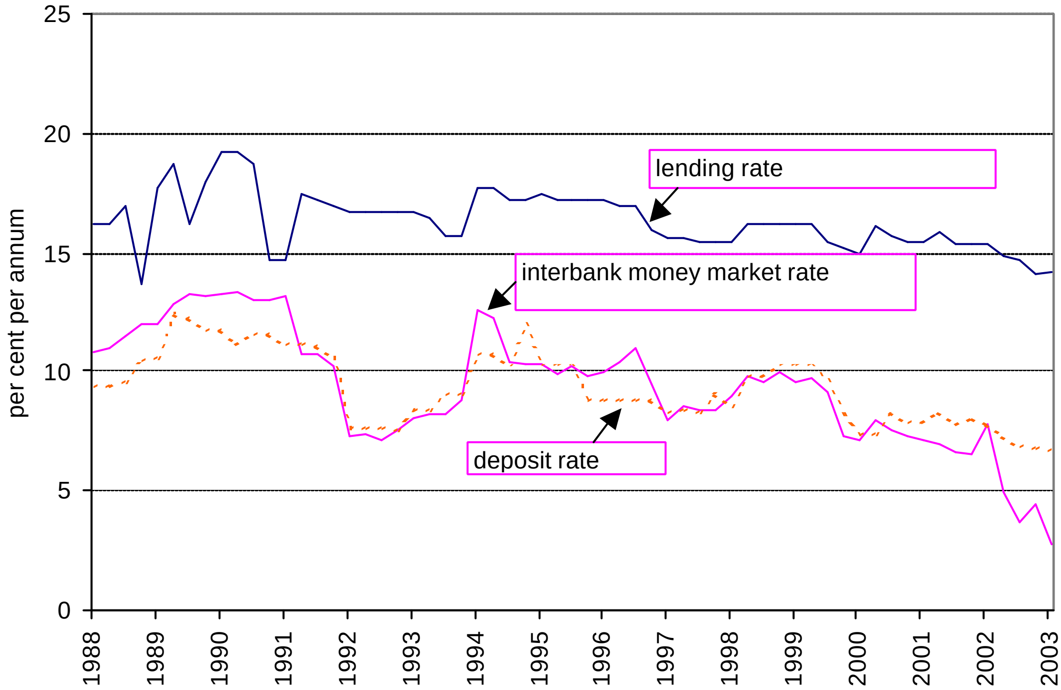
Table 1: Unit Root Test Results[a]

Variables	Level	First Difference
Deposit Rate (DEPR)	-2.48	-3.91**
Lending Rate (LENR)	-1.63	-4.03**
Interbank Money Market Rate (IBR)	-0.94	-3.24**

[a] without trend but including an intercept term in the test specification.**statistically significant at 1% level. Critical values at first difference are -2.61, -1.95 and -1.61 at 1%, 5% and 10% levels respectively.

Figure 1 shows the evolution of the three interest rates over the period of study. Both deposit and lending interest rates seems to be highly correlated with the interbank money market rate. This is an indication that both retail rates are very likely to be cointegrated with the wholesale rate.

Figure 1: Trends in Interest Rates



6. Estimation and Analysis

We apply the Johansen's (1988) procedure to detect any cointegrating relationships between the respective retail rates and the wholesale rate. Table 2 displays the results of the tests. The models incorporate an intercept term but no deterministic trend in the potential cointegrating vectors. The lag selection is based on the Akaike Information Criteria (AIC) which suggests three lags in the deposit rate model and one lag in the lending rate model. In both cases, the eigen and trace statistics support the evidence of a long-run relationship between the retail rate and the interbank rate.

Table 2: Johansen Cointegration Test

Hypothesised No. of CE	Maximum Eigen Statistic	5% Critical Value	Trace Statistic	5% Critical Value
Deposit-Interbank Rate Model				
None	22.83*	15.67	24.87*	19.96
At most 1	2.03	9.24	2.03	9.24
Normalised Cointegrating vector: DEPR - 0.55 IBR (-0.05) - 4.21 (-0.45)				
Lending-Interbank Rate Model				
Hypothesised No. of CE	Maximum Eigen Statistic	5% Critical Value	Trace Statistic	5% Critical Value
None	24.71*	15.67	26.15*	19.96
At most 1	1.44	9.24	1.44	9.24
Normalised Cointegrating vector: LENR - 0.33 IBR (-0.06) - 13.31 (-0.62)				

Standard errors are given in parentheses. * denotes rejection of the null hypothesis at the 5% level.

Using the cointegrating residuals from both long-run equations, we then estimate the TAR model for deposit rate (column1, Table 3) and lending rate (column1, Table 4). The number of lags to be included in the models is determined on the basis of the LM test of serial correlation. However, none of the models require any lagged terms. A Wald test is carried out to test the null hypothesis of no cointegration (i.e, $r_1 = r_2 = 0$). The sample value of j_m-statistic (9.015 for the deposit rate model and 16.857 for the lending rate model) being greater than the critical value, 6.20 at the 5% level (Enders and Siklos, 2001), we reject the null hypothesis and conclude that the retail rates and the wholesale rate are cointegrated. Note that such critical values are usually sensitive to the number of variables included in the regression. However, since this model entails only two variables and similar to the 2-variable model estimated by Enders and Sikos (2001), the use of their critical values is valid. Given evidence of cointegration, we then test for any asymmetric adjustment (i.e, $r_1 = r_2$) using the standard F-distribution. Since the p-values (0.5342 for the deposit rate model and 0.3013 for the lending rate model) for the test statistics are greater that 5%, we conclude that the adjustment process is symmetric for both deposit and lending rates.

The M-TAR model is estimated next for the deposit rate (column 2, Table 3) and lending rate (column 2, Table 4) respectively. On the basis of LM test for serial correlation we again determine the number of lagged terms in $\{\Delta\hat{m}_t\}$. The LM test favours no lags in the deposit rate model but two lags in the lending rate model.

Table 3: Estimates of the Deposit Rate Adjustment Process

	TAR	M-TAR	Augmented Dickey-Fuller
r_1	-0.400 (-2.57)	-0.495 (-3.36)	-0.468 (-4.22)
r_2	-0.540 (-3.38)	-0.460 (-2.58)	-
R^2	0.236	0.238	0.230
D.W.	1.996	2.009	2.008
AIC	1.797	1.811	1.770
LM-test[a]	0.286 (0.8670)	0.820 (0.6637)	0.634 (0.7283)
j_m [b]	9.015	8.980	-
$r_1 = r_2$ [c]	0.391 (0.5342)	0.023 (0.8803)	-

Note: g_1 and g_2 are the estimated coefficients of the lagged changes in the $\{\hat{m}_t\}$. t-statistics for $r's$ and $g's$ are given in parentheses. [a] Breusch-Godfrey LM test statistics for the null hypothesis that there is no serial correlation. P-values are given in parentheses. [b] Sample values of j_m. Critical values for j_m (Enders and Siklos, 2001) for a two-variable case with no lagged terms are 5.09, 6.20 and 8.78 at 10%, 5% and 1% respectively. [c] F-statistics for the null hypothesis that the adjustment coefficients are equal. P-values are given in parentheses.

The sample values of the j_m-statistic are once again compared to the critical values computed by Enders and Siklos (2001). In the deposit rate model, the sample statistics, 8.980 is compared to be 5% critical value of 6.20 while in the lending rate model, the sample statistics, 8.847 is compared to the 5% critical value of approximately 6.18 (given 2 lagged terms in the model). In both models, we again find evidence of cointegration between the retail rates and the wholesale rate. A test of symmetry using the F-distribution gives test statistics with p-values 0.8803 for deposit rate model and 0.0571 for lending rate model. Once again we find no evidence of asymmetry in the deposit rate model. However, at the 10% level we can now reject the null hypothesis of symmetry in the lending rate process. This finding suggests that the adjustment process for lending rate is asymmetric in the sense that a positive shock to the margin between lending rate and interbank rate tends to persist while a negative tends to quickly revert towards the mean (i.e, zero).

Table 4: Estimates of the Lending Rate Adjustment Process

	TAR	M-TAR	Momentum-Consistent	Augmented Dickey-Fuller
r_1	-0.798 (-5.28)	-0.756 (-4.00)	-0.862 (-4.51)	-0.708 (-5.71)
r_2	-0.523 (-2.41)	-0.140 (-0.41)	-0.134 (-0.49)	-
g_1	-	0.011 (0.07)	0.052 (0.35)	-
g_2	-	-0.220 (-1.67)	-0.22 (-1.72)	-
R^2	0.368	0.436	0.467	0.356
D.W.	1.872	1.760	1.542	1.901
AIC	2.668	2.655	2.597	2.653
LM-test[a]	2.433 (0.2962)	5.188 (0.0747)	3.841 (0.1466)	1.929 (0.1547)
j_m [b]	16.857	8.847	10.996	-
$r_1 = r_2$ [c]	1.808 (0.3013)	3.780 (0.0571)	7.243 (0.0095)	-

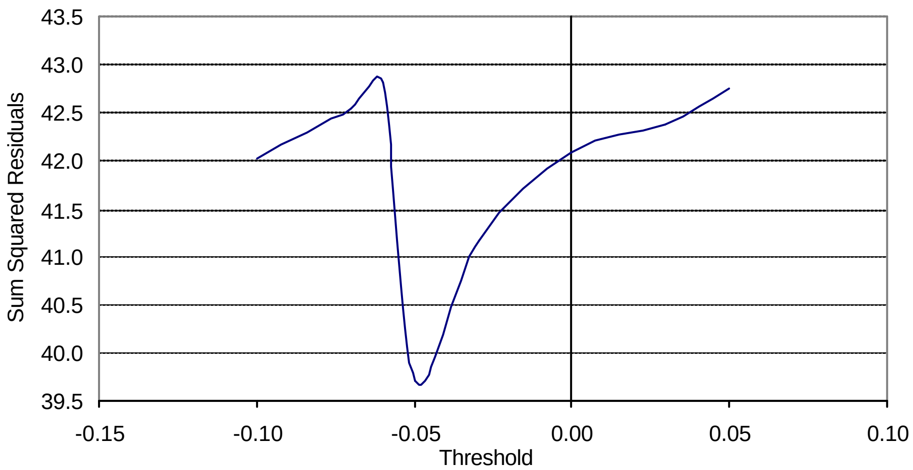
Note: g_1 and g_2 are the estimated coefficients of the lagged changes in the $\{\hat{m}_t\}$. t-statistics for $r's$ and $g's$ are given in parentheses. [a] Breusch-Godfrey LM test statistics for the null hypothesis that there is no serial correlation. P-values are given in parentheses. [b] Sample values of j_m and j_m^*. Critical values for j_m (Enders and Siklos, 2001) for a two-variable case with no lagged terms are 5.09, 6.20 and 8.78 at 10%, 5% and 1% respectively. Critical values for j_m (Enders and Siklos, 2001) for a two-variable case with two lagged terms are approximately 5.08, 6.18 and 8.67 at 10%, 5% and 1% respectively. The corresponding values of j_m^* (Enders and Siklos, 2001) are 6.20, 7.31 and 10.0 at 10%, 5% and 1% respectively. [c] F-statistics for the null hypothesis that the adjustment coefficients are equal. P-values are given in parentheses.

For comparison, we also report results of a symmetric adjustment process in deposit rate and lending rate in the last columns of Tables 3 and 4 respectively which is equivalent to a Dickey-Fuller test on the residuals. For both retail rates, the t-statistics for the null hypothesis that $r_1 = 0$ (-4.22 for deposit rate model and –5.71 for lending rate model) are found to be larger than the 5% critical value of the Augmented Dickey Fuller test (-2.91), indicating that the retail rates are cointegrated. Interestingly, the adjustment coefficient in the symmetric models lie somewhere between the estimated values of r_1 and r_2 in the TAR and M-TAR models.

6.1 Searching for Threshold Level

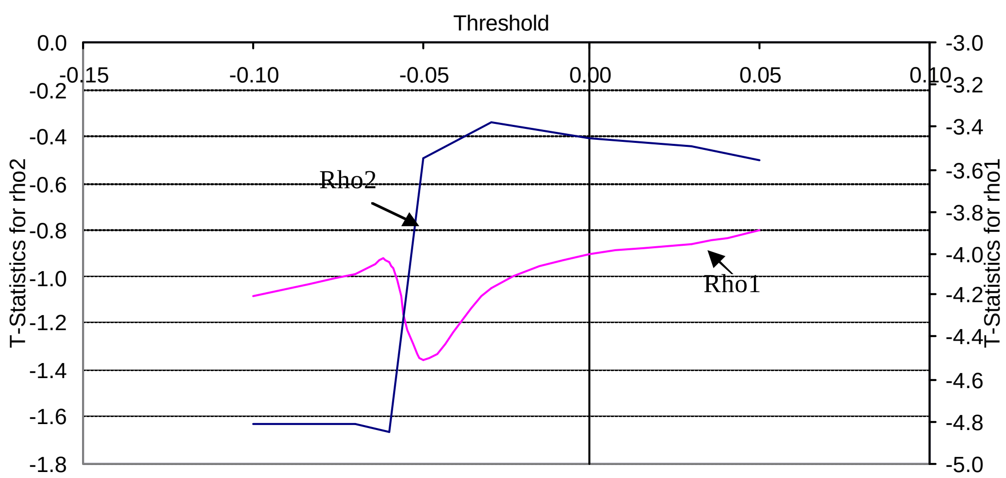
In a model with asymmetric adjustment, Tong (1983) demonstrated that the sample mean is a biased estimate of the trend or attractor. In a TAR model such as (5) and (6), if $|r_1| < |r_2|$, the sequence $\{\hat{m}_t\}$ exhibits relatively more persistence whenever $\hat{m}_{t-1} < 0$. In such circumstances, the value of the attractor (i.e., 0) will exceed the mean of the series. Chan (1993) showed that searching over the possible threshold values so as to minimize the sum of squared errors from the fitted model would yield a super-consistent estimate of the threshold.

Figure 2: Squared Sum of Residuals



Using Chan's (1993) method, we therefore determine the consistent threshold estimate for the adjustment process of lending rate. This entails first arranging in ascending order, the sequence $\{\Delta\hat{m}_t\}$. At both ends, about 20 observations are discarded (to allow the samples below and above the threshold to be reasonably large) and the possible threshold is searched over the middle values. Equations (9) and (10) are then estimated over a grid of possible threshold values and the sum of squared errors (SSE) of the fitted model are recorded along with the t-statistics corresponding to the coefficients r_1 and r_2 (Figures 2 and 3 respectively). The consistent estimate of the threshold which yields the minimum SSE, is found to be -0.05. The M-TAR model is again estimated for lending rate using this value of the threshold (Column 3, Table 4). The model is again estimated using two lagged changes in $\{\Delta \hat{m}_t\}$. The sample value j^{*}_{m} which is the analogue of j_{m} (for a known threshold) is 10.996. We thus compare it to the 5% critical value of 7.31 (Enders and Siklos, 2001) which allows us to soundly reject the null hypothesis of no cointegration. The Wald test of symmetry is also strongly rejected with a p-value of 0.0095. On the basis of the AIC, the M-TAR model with the consistent estimate of the threshold appears to have the best fit among all the estimated models.

Figure 3: Significance of the Rho-Coefficients



6.2 Asymmetric Error-Correction Model for Lending Rate With Threshold level

Having found out that the adjustment process of lending rates is asymmetric, it will be incorrect to examine the short-run dynamics with a symmetric error correction model. We therefore specify an error correction model as per equation (8),

$$\Delta \mathrm{LENR}_t = a_2 + A_1(L)\Delta \mathrm{LENR}_{t-1} + A_2(L)\Delta \mathrm{IBR}_{t-1} + l_1 \mathrm{ECT}^{-}_{t-1} + l_2 \mathrm{ECT}^{+}_{t-1} + u_t \qquad (11)$$

where

$$\begin{aligned} \mathrm{ECT}^{-}_{t-1} &= \hat{m}_{t-1} \quad \text{if} \quad \Delta \hat{m}_{t-1} < -0.05, \qquad 0 \ \text{otherwise} \\ \mathrm{ECT}^{+}_{t-1} &= \hat{m}_{t-1} \quad \text{if} \quad \Delta \hat{m}_{t-1} \geq -0.05, \qquad 0 \ \text{otherwise} \end{aligned} \qquad (12)$$

$A_j(L)$ are polynomials in the lag operator L and the l_i's are the speed of adjustment coefficients. The estimation of an error correction model for the interbank rate is not required given that the latter is assumed to be exogenous. Note that ECT^{-}_{t-1} and ECT^{+}_{t-1} are the error correction terms from the M-TAR model and represents adjustments to negative and positive shocks to the margin, respectively.

Table 5: Estimates of the Error Correction Model for Lending Rate

	Asymmetric Error Correction	Symmetric Error Correction
Constant	-0.077 (-0.76)	0.039 (0.42)
$\Delta\,\mathrm{LENR}_{t-1}$	0.419 (2.67)	0.441 (2.70)
$\Delta\,\mathrm{LENR}_{t-2}$	-0.273 (-2.21)	-0.242 (-1.89)
$\Delta\,\mathrm{LENR}_{t-3}$	0.262 (2.16)	0.285 (2.27)
$\Delta\,\mathrm{LENR}_{t-4}$	-0.512 (-1.52)	-0.096 (-0.95)
$\Delta\,\mathrm{LENR}_{t-5}$	0.114 (1.06)	-0.246 (2.581)
$\Delta\,\mathrm{IBR}_{t}$	0.242 (2.86)	0.215 (2.47)
ECT^{-}_{t-1}	-0.803 (-4.39)	-
ECT^{+}_{t-1}	-0.144 (-0.56)	-
ECT_{t-1}	-	-0.601 (-3.58)
R^2	0.594	0.548
D.W.	1.854	1.924
AIC	2.051	2.123
LM-test[a]	2.032 (0.1073)	2.532 (0.0540)
F [b]	5.426 (0.0005)	5.059 (0.0009)
$l_1 = l_2$ [c]	5.276 (0.0262)	-

Note: t-statistics in parentheses for the estimated coefficients. [a] Breusch-Godfrey LM test statistics for the null hypothesis that there is no serial correlation. P-values are given in parentheses. [b] F-test statistics to test the null hypothesis that the lagged terms of $\Delta\,\mathrm{LENR}_t$ are jointly equal to zero. Corresponding p-values are given in parentheses. [c] F-statistics for the null hypothesis that the adjustment coefficients are equal. Corresponding p-values are given in parentheses.

Table 5 presents the results of the error correction model. Using a general to specific approach, the number of lagged terms is selected. For purpose of comparison, we also report estimates of a symmetric error correction model. The t-statistics of the error correction terms, ECT_{t-1}^{-} and ECT_{t-1}^{+} indicate that lending rate responds strongly to negative shocks to margin but whenever there are positive shocks to the margin, no convergence takes place. Thus, discrepancies are eliminated at a speed of 0.803 units every quarter for negative shocks to the margin but are allowed to persist for positive shocks. The coefficients of the contemporaneous and lagged terms of the changes in interbank rate and lending rate seem to have a significant impact on lending rate (given a t-statistic of 2.86 for $\Delta \mathrm{IBR}_t$ and a p-value of less than 5% for the F-test on the joint significance of the lagged changes in lending rate). The null hypothesis of symmetry in the adjustment coefficients (i.e, $l_1 = l_2$) is tested using the Wald test. Given a p-value of 0.0262, we reject the null hypothesis and conclude that the adjustment process of lending rate is indeed asymmetric.

Table 6: Estimates of the Error Correction Model for Deposit Rate

	Symmetric Error Correction
Constant	0.021 (0.36)
$\Delta \mathrm{DEPR}_{t-2}$	0.234 (2.67)
$\Delta \mathrm{DEPR}_{t-3}$	0.313 (3.41)
$\Delta \mathrm{IBR}_t$	0.413 (6.28)
ECT_{t-1}	-0.641 (-5.87)
R^2	0.599
D.W.	1.853
AIC	1.586
LM-test[a]	1.693 (0.7920)
F [b]	18.660 (0.0000)

Note: t-statistics in parentheses for the estimated coefficients. [a] Breusch-Godfrey LM test statistics for the null hypothesis that there is no serial correlation. P-values are given in parentheses. [b] F-test statistics to test the null hypothesis that the lagged terms of $\Delta \mathrm{DEPR}_t$ are jointly equal to zero. P-values are given in parentheses.

A symmetric error-correction model (column2, Table 5) is also estimated (where $ECT_{t-1} = LENR_{t-1} - 0.33\, IBR_{t-1} - 13.31$) and the speed of adjustment coefficient is estimated at –0.601. Once again, AIC favours the asymmetric error correction model to the symmetric one. Given no evidence of asymmetry in the deposit rate, we report the estimates of a symmetric error-correction model in Table 6 (where $ECT_{t-1} = DEPR_{t-1} - 0.55\, IBR_{t-1} - 4.21$). The coefficient of the change in interbank rate is positive and significant which shows that deposit rate responds positively to any shock in interbank rate. As a matter of fact, the response of deposit rate to a change in the interbank rate is larger (0.413) than the response of lending rate (0.242) to any change in the interbank rate. The lagged terms for the changes in deposit rate are also statistically significant given the p-value of zero for the F-test conducted to test their joint significance. The speed of adjustment coefficient, -0.641 is statistically significant at the 5% level. This indicates that long-run disequilibria between deposit rate and interbank rate are corrected at the speed of 0.641 every quarter irrespective of whether the discrepancies between deposit rate and interbank rate are above or below their long-run equilibrium.

7. Conclusions

The purpose of this study is to examine the rigidity in commercial banks' retail rates following a change in the wholesale rate, within a non-linear framework. Using the technique proposed by Enders and Siklos (2001) which is an extension to the model developed by Enders and Granger (1998), asymmetry is tested on the Mauritian interest rates for the period 1988:Q1 to 2003:Q3. In particular, we examine the response of commercial banks' deposit and lending rates to a change in the interbank rate which the central bank influences indirectly through its daily open market operations. Enders and Granger (1998) proposed two different specifications to test for non-linearity: the threshold autoregressive (TAR) model and the momentum-TAR (M-TAR) model. These two specifications not only detect whether or not there is asymmetry, but also distinguish between *deep* and *sharp* cycles. In particular, the TAR model captures the *deepness* of cycles where the negative discrepancies can converge more rapidly towards the long-run equilibrium as compared to positive discrepancies. On the other hand, the M-TAR captures the *steepness* of cycles such that contractions can be steeper than expansions.

Asymmetry in retail rates to changes in the interbank rate is tested using both specifications. The TAR-model does indicate that both retail rates are cointegrated with the interbank rate but no asymmetry is found in the adjustment of positive and negative discrepancies towards their equilibrium level. The M-TAR model is then estimated and this time there is some evidence of asymmetric behaviour for *increases and decreases in margin* where the margin is the difference between the retail rate and the interbank rate. However, such asymmetry is detected only for lending rate while adjustment in deposit rates is once again found to be symmetric. The asymmetry in the adjustment of lending rates suggests that discrepancies between lending rate and interbank rate from their long-run equilibrium level, are found to be eliminated rather quickly (0.803 units every period) when there are negative shocks to the margin but others are allowed to persist, i.e., discrepancies from the long-run equilibrium exhibit more momentum when they are declining than when they are increasing. In other words, whether interbank rate is increasing or decreasing, lending rates are adjusted more rapidly for decreases in the margin but they are allowed to persist for increases in the margin. Thus, rigidity is observed in lending rate increases or decreases if the margin between lending rate and interbank rate widens as against a contraction in the margin.

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