A MULTIPLE-REGIME ECONOMETRIC MODEL OF INFLATION FOR MAURITIUS

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Abstract

This paper estimates a semi-multivariate dynamic model of Mauritian inflation, using monthly data over the period January 1976 - December 2001, which captures the significant nonlinearity and asymmetry present in the inflation process. Starting from a linear autoregressive distributed lag (ARDL) model, asymmetric nonlinearity is found and modelled using a logistic smooth transition regression (LSTR) model. The LSTR model, while producing an improvement in fit over the ARDL model, contains significant autocorrelation and fails tests of parameter constancy and remaining nonlinearity. A logistic multiple-regime smooth transition regression (LMRSTR) model is then estimated, constituting a marked improvement over the LSTR model and hence the linear ARDL model. A simulation exercise produces interesting findings on the dynamic effects of the Rs./$ exchange rate on Mauritian inflation and demonstrates the superiority of the LMRSTR model over the conventional ARDL model.

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This paper estimates a semi-multivariate dynamic model of Mauritian inflation, using monthly data over the period January 1976 - December 2001, which captures the significant nonlinearity and asymmetry present in the inflation process. Starting from a linear autoregressive distributed lag (ARDL) model, asymmetric nonlinearity is found and modelled using a logistic smooth transition regression (LSTR) model. The LSTR model, while producing an improvement in fit over the ARDL model, contains significant autocorrelation and fails tests of parameter constancy and remaining nonlinearity. A logistic multiple-regime smooth transition regression (LMRSTR) model is then estimated, constituting a marked improvement over the LSTR model and hence the linear ARDL model. A simulation exercise produces interesting findings on the dynamic effects of the Rs./$ exchange rate on Mauritian inflation and demonstrates the superiority of the LMRSTR model over the conventional ARDL model.

1. Introduction

Formal inflation targeting, first adopted in 1990 by New Zealand, is nowadays being practised by developed countries (including the United Kingdom, Canada, Sweden and Australia) as well as emerging countries (including South Africa, Mauritius and Turkey). The practice of explicit inflation targeting, typically in the form of a fixed-point or a target range, renders imperative the design of sound econometric models that can forecast inflation accurately and assess the effects of economic shocks on the inflation process. For example, in the United Kingdom where there is a fixed-point inflation target of 2.5%, econometric models at the Bank of England are used to help the Monetary Policy Committee make its forecast for inflation and output growth, published quarterly in the Inflation Report. These models are, in addition, used to simulate the effects of possible changes in the way that inflation
expectations are formed. In South Africa, since the introduction of inflation targeting in February 2000 in the form of a target range, considerable effort has been devoted to the development of state-of-the-art inflation forecasting models. As mentioned in Mnyande (2002), these models have become the cornerstone in assessing the prospects for inflation and growth in the economy. Mauritius has also adopted explicit inflation targeting since fiscal year 1997/98. The announced inflation target for Mauritius has been a fixed-point for some years and a range for other years. For instance, the target announced was 6% for fiscal year 1999/00, 5% - 5.5% for 2000/01 and 2001/02, and around 6% for 2002/03.


The present paper, after showing that a linear ARDL equation is inadequate, estimates a logistic multiple-regime smooth transition regression (LMRSTR) model of monthly inflation for Mauritius over the period 1976M1 - 2001M12. Section 2 briefly outlines the models that

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1 See Economic Models at the Bank of England (Bank of England, 1999) for details
2 Inflation targets obtained from Bank of Mauritius Annual Reports. The fiscal year runs from July of a calendar year to June of the following calendar year.
3 To my knowledge, no rigorously estimated inflation model has been published for Mauritius before.
have been typically applied to explain and forecast inflation in emerging countries. Section 3 provides and justifies the econometric methodology adopted in this paper. Section 4 contains the empirical findings. Section 5 concludes.

2. Economic Models of Inflation

There are, broadly speaking, three classes of models for inflation determination that have been applied to emerging countries, namely mark-up models, monetary models and Phillips curve models. These models, which are popular and easily accessible, are briefly outlined below.

In mark-up models, where inflation is viewed as a cost-push phenomenon, the price level is determined by costs plus a given mark-up. The cost component typically includes wages, the nominal exchange rate and the level of import prices. Subject to the assumption of a stationary mark-up, this model implies the existence of a cointegrating relation between domestic prices, wages, exchange rate and foreign prices. This ultimately produces an error-correction equation for inflation.4

Monetary models view inflation as being primarily a monetary phenomenon. Inflation here responds to previous inflation and the lagged money gap, which is typically obtained as the disequilibrium error from a long-run money demand equation. The money gap model also implies an error-correction equation for inflation.5

The typical Phillips curve model relates inflation to inflation expectations, some measure of real disequilibrium (typically the output gap) and indicators of cost push pressures (e.g. the exchange rate and import prices).6

4 For details and applications of the mark-up model, see de Brower and Ericsson (1998) and Garcia and Restrepo (2001).
5 For details and an application of the money gap model, see Coe and McDermott (1999).
6 For details and an application of the traditional Phillips curve model, see BGKM (2002).
3. Econometric Methodology

3.1 Justification

The inflation equations estimated for emerging countries have so far essentially been of the linear ARDL type, where domestic inflation is regressed on its own lags, the current and lagged values of exogenous variables (such as the exchange rate change, the money gap, the output gap, growth in labour costs, and imported price inflation) and a lagged error-correction term. The ARDL model, like any linear model, has several implications and limitations from a modelling perspective in the case of a variable like inflation.

First, a linear model would imply that the inflation response to exogenous shocks is symmetric. For instance, a 10% appreciation of the US dollar vis-a-vis the Mauritian rupee will have exactly the opposite effect on the inflation path as a 10% depreciation of the dollar vis-a-vis the rupee. Second, a linear model has the property of proportionality, i.e. a 10% appreciation of the US dollar vis-a-vis the Mauritian rupee will have twice an effect on inflation as a 5% appreciation of the dollar vis-a-vis the rupee. Linearity also means that the response of inflation to shocks would be the same regardless of the history preceding the shocks. For example, whether the dollar is weak or strong, a money supply shock would have the same effect on inflation. Last, but not least, a linear model would only be able to accommodate abrupt changes in regime, through the inclusion of dummy variables. Smooth regime changes, which are likely to be relevant when modelling a variable like inflation over a long time period, cannot be captured by linear models.

This paper presents a LMRTSR model of Mauritian inflation. This nonlinear dynamic model can account for asymmetric inflation response, non-proportional response, history dependence in response to shocks, and smooth as well as abrupt regime changes. Nonlinear and asymmetric models of inflation have so far been estimated for a few developed countries
3.2 Modelling Strategy

A specific-to-general modelling strategy is adopted. The starting point is an ARDL model where the current domestic price level depends on a set of deterministic variables, previous values of the price level, and the current and lagged values of exogenous variables.

\[
\alpha(L)y_t = \theta/z_t + \lambda(L)/x_t + \varepsilon_t
\]  

where \( t = 1, 2, \ldots, T \)

\( y_t \) is the natural logarithm of the price level

\( z_t \) is a vector of deterministic variables containing a constant and seasonal dummy variables

\( \theta \) is the parameter vector associated with \( z_t \)

\( x_t = [x_1, x_2, \ldots, x_q]' \) is a vector of \( q \) exogenous variables, expressed in natural logarithm

\( \alpha(L) = 1 - \sum_{i=1}^{p} \alpha_i L^i \) is a lag polynomial in the domestic price level

\( \lambda(L) = [\lambda_1(L), \lambda_2(L), \ldots, \lambda_q(L)]' \) is a vector lag polynomial in the exogenous variables

and \( \lambda_k(L) = \sum_{i=0}^{p} \lambda_{ki}; k = 1, 2, \ldots, q \)

\( \varepsilon_t \) is an \( IID(0, \sigma^2) \) error process

The above model may be reparameterised to obtain an ARDL model for inflation as follows

\[
\Delta y_t = \theta'z_t + \sum_{k=1}^{q} \lambda_{k0} \Delta x_{kt} + \pi y_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + \sum_{k=1}^{q} \sum_{i=1}^{p-1} \pi_{kx} x_{k,t-i} + \sum_{k=1}^{p-1} \gamma_{ki} \Delta x_{k,t-i} + \varepsilon_t
\]  

\footnote{For an application of two-regime threshold models of inflation for United States and Canada, see Tkacz (2002). For a model of inflation targeting applied to Canada, Sweden and United Kingdom, where the central banker has asymmetric preferences, see Ruge-Murcia (2001).}
where \( t = (\text{trimup} + 1), \ldots, T \)

\( \text{trimup} \) = number of initial observations deleted to accommodate for created lagged variables

\( \Delta = (1 - L) \) is the first-difference operator

\[ \pi_y = -\alpha(1) \]

\[ \beta_i = -\sum_{j=i+1}^{p} \alpha_j; \quad i = 1, 2, \ldots, (p - 1) \]

\[ \pi_{kx} = \sum_{j=0}^{p} \lambda_{kj}; \quad k = 1, 2, \ldots, q \]

\[ \gamma_{kt} = -\sum_{j=i+1}^{p} \lambda_{kj}; \quad i = 1, 2, \ldots, (p - 1); \quad k = 1, 2, \ldots, q \]

The ARDL model in (2) is estimated and the lag order is chosen as the minimum value of \( p \) which implies no residual autocorrelation. As explained above, the ARDL imposes a number of restrictions on the response of inflation to shocks. The present paper proposes to relax and evaluate these restrictions by using a class of nonlinear models known as smooth transition regression (STR) models.\(^8\) In the light of recent research pointing to an asymmetry in the preferences of the central banker under inflation targeting (see Ruge-Murcia, 2001), this paper first investigates the possibility of asymmetric nonlinearity in the dynamics of Mauritian inflation with a logistic STR (LSTR) model.

The ARDL model in (2) is rewritten in a more compact form

\[ \Delta y_t = \varphi' w_t + \varepsilon_t \quad (3) \]

where \( \varphi' w_t = \theta' z_t + \sum_{k=1}^{q} \lambda_{k0} \Delta x_{kt} + \pi_y y_{t-1} + \sum_{i=1}^{p-1} \beta_i \Delta y_{t-i} + \sum_{k=1}^{q} (\pi_{kx} x_{k,t-1} + \sum_{i=1}^{p-1} \gamma_{ki} \Delta x_{k,t-i}) \]

The LSTR model, which is a two-regime switching model, is formulated as follows

\[ \Delta y_t = \varphi' w_t + \Gamma' \tilde{w}_t G(s_{yt}, \eta_{yt}, c_y) + \xi_t \quad (4) \]

\(^8\) For a recent survey on STR models, see van Dijk, Terasvirta and Franses (2002).
where $t = (\text{trimup} + 1), \ldots, T$

$\text{trimup}$ is as defined above.

$$G(s_{gt}, \eta_g, c_g) = \left\{ \left[ 1 + \exp\{-\eta_g(s_{gt} - c_g)\} \right]^{-1} - 0.5 \right\}$$

is a transition function which is continuous in $s_{gt}$ and bounded between $-0.5$ and $0.5$.

$\tilde{w}_t$ contains all the elements of $w_t$, except seasonal dummies.

$\xi_t$ is an $\text{IID}(0, \sigma^2_{\xi})$ error process.

The transition variable $s_{gt}$ is a stationary variable or a time trend.\footnote{The annual difference of $y_t$ ($\Delta_{12}y_{t-j}$) and of the exogenous variables in $x_t$ ($\Delta_{12}x_{k,t-j}$), where $k = 1, \ldots, q$ and $j = 1, \ldots, 12$, are investigated as potential transition variables in this paper. This implies that the number of initial observations deleted ($\text{trimup}$) equals 24.}

The location parameter $c_g$ determines the value of $s_{gt}$ at which the sign of the transition function $G$ switches.

Under the null hypothesis of linearity ($H_0 : \eta_g = 0$), the transition function $G$ equals zero and the LSTR model (4) reduces back to the ARDL model (3). Asymmetric nonlinearity occurs when $\eta_g > 0$, which in turn implies that $G$ is non-zero. The magnitude of the adjustment parameter $\eta_g$ determines the speed of transition from one regime to another. A small value of $\eta$ implies a smooth and gradual transition while a large value implies a fast transition. In the limit, when $\eta_g = +\infty$, the transition function $G$ becomes a Heaviside function implying an abrupt transition at the point $s_{gt} = c_g$, and the resulting model is called a threshold regression (TR) model.

The evaluation of the null hypothesis of linearity is based on a first-order Taylor approximation to $G$ about $\eta_g = 0$ (see Terasvirta (1998) for details). This procedure leads to an auxiliary equation for inflation

$$\Delta y_t = \phi'_0 w_t + \phi'_1(\tilde{w}_t s_{gt}) + u_t \quad (5)$$
where $u_t$ is a composite error process

Linearity, based on the null hypothesis ($H_0: \phi_1 = 0$), is evaluated with a conventional $F$ test for a range of potential transition variables. The selected transition variable for the LSTR model is the one which, based on a given significance level, produces the minimum $p$-value for the $F$ test. The LSTR model is estimated by nonlinear least squares, with starting values based on a 2-dimensional grid search for $\eta_g$ and $c_g$. The estimated LSTR model is subject to tests of autocorrelation, conditional heteroscedasticity, parameter constancy and remaining nonlinearity (see Eirtheim and Terasvirta (1996) for details).

As the two-regime LSTR model is found to be unsatisfactory in explaining the dynamics of Mauritian inflation, a logistic multiple-regime smooth transition regression (LMRSTR) model is specified as follows

$$\Delta y_t = \psi / w_t + \Phi / \tilde{w}_t G(s_{gt}, \nu_g, d_g) + \Lambda / \tilde{w}_t H(s_{ht}, \nu_h, d_h) + \Omega / \tilde{w}_t G(s_{gt}, \nu_g, d_g) H(s_{ht}, \nu_h, d_h) + \xi_t^*$$

(6)

where $t = (trimup + 1), \ldots, T$

$G(s_{gt}, \nu_g, d_g) = \{1 + \exp\{-\nu_g(s_{gt} - d_g)\}\}^{-1} - 0.5$ is a logisitc transition function with known transition variable $s_{gt}$ (from LSTR model (4)), and unknown location and adjustment parameters $d_g$ and $\nu_g$

$H(s_{ht}, \nu_h, d_h) = \{1 + \exp\{-\nu_h(s_{ht} - d_h)\}\}^{-1} - 0.5$ is also a logistic transition function with unknown transition variable $s_{ht}$, location parameter $d_h$, and adjustment parameter $\nu_h$

$w_t$ and $\tilde{w}_t$ are as defined above

$\xi_t^*$ is an $IID(0, \sigma_{\xi_t}^2)$ error process

Note that if $s_t$ is a time trend, the $F$ statistic produces a test of parameter constancy in the linear ARDL model.
Based on the estimated LSTR model (4), the unknown transition variable $s_{ht}$ for the transition function $H$ in the LMRSTR model (6) is determined from the following equation (see van Dijk and Franses (1999) for details)

$$
\Delta y_t = \tau_0 w_t + \tau_1 \tilde{w}_t \hat{G}(t) + \tau_2 (\hat{G}/ \hat{w}_t \hat{G}_v(t)) + \tau_3 (\hat{G}/ \hat{w}_t \hat{G}_d(t)) + \rho_1 (\tilde{w}_t s_{ht}) + \rho_2 (\tilde{w}_t s_{ht} \hat{G}(t)) + u^*_t \tag{7}
$$

where $t = (trimup + 1), \ldots, T$

$\hat{G}(t) = G(s_{gt}, \hat{v}_g, \hat{d}_g)$

$\hat{G}_v(t) = \frac{\partial G(s_{gt}, \hat{v}_g, \hat{d}_g)}{\partial v_g}$

$\hat{G}_d(t) = \frac{\partial G(s_{gt}, \hat{v}_g, \hat{d}_g)}{\partial d_g}$

$u^*_t$ is a composite error process

The detection of LMRSTR nonlinearity is based on the null hypothesis $H_0 : \rho_1 = \rho_2 = 0$, which is evaluated using a conventional $F$ test. Equation (7) is run several times with a range of variables acting as transition variable $s_{ht}$. The transition variable $s_{ht}$ is selected as the one which, based on a given significance level, produces the minimum $p$-value for the null hypothesis $H_0 : \rho_1 = \rho_2 = 0$. The LMRSTR model is estimated by nonlinear least squares, with starting values based on a 4-dimensional grid search for $\nu_g, d_g, \nu_h$ and $d_h$. The estimated LMRSTR model, which is in fact a four-regime model, passes a range of diagnostic tests and does prove to be a good model of inflation dynamics for Mauritius.

### 3.3 Simulation exercise

The dynamics of the LMRSTR equation (6) and the linear ARDL equation (2) are investigated through a simulation exercise, whereby the effect on inflation is obtained following
a shock to the path of a single exogenous variable over a given horizon. The simulated inflation response \( SIR \) is expressed as

\[
SIR_{t+r} = E(\Delta y_{t+r}/I_{t-1}, X_{t+h_{\text{max}}}^{\text{shocked}}) - E(\Delta y_{t+r}/I_{t-1}, X_{t+h_{\text{max}}}^{\text{historical}})
\]

(8)

where \( r = 0, 1, \ldots, h_{\text{max}} \) is the horizon over which the path of the exogenous variable is shocked and the effect on inflation is simulated

\[ t = (\text{trimup} + p), \ldots, (T - h_{\text{max}}) \] represents the initial shock period

\( I_{t-1} \) represents information prior to the initial shock period

\( X_{t+h_{\text{max}}}^{\text{historical}} \) is the historical matrix of the exogenous variables between the initial shock period and the maximum horizon investigated inclusive

\( X_{t+h_{\text{max}}}^{\text{shocked}} \) is the shocked matrix of the exogenous variables between the initial shock period and the maximum horizon investigated inclusive

For a given initial shock period \( t \), a shocked path for inflation is simulated over the horizon \( h_{\text{max}} \), producing a series of \( (h_{\text{max}} + 1) \) shocked observations. The same is done for all initial shock periods and the results are organised into a \( (h_{\text{max}} + 1) \times (T - h_{\text{max}} - \text{trimup} - p + 1) \) matrix, where a given column contains the simulated shocked inflation path with respect to a given initial shock period. The average across a given row of this matrix estimates the simulated shocked inflation value \( r \) periods ahead of the initial shock period. An estimate of \( E(\Delta y_{t+r}/I_{t-1}, X_{t+h_{\text{max}}}^{\text{shocked}}) \) is thus the sample mean

\[
(\Delta y_{t+r}/I_{t-1}, X_{t+h_{\text{max}}}^{\text{shocked}}) = \frac{\sum_{t=(\text{trimup}+p)}^{(T-h_{\text{max}})} (\Delta y_{t+r}/I_{t-1}, X_{t+h_{\text{max}}}^{\text{shocked}})}{(T - h_{\text{max}} - \text{trimup} - p + 1)}; r = 0, 1, \ldots, h_{\text{max}}
\]

Note that it is a variable in the model which is shocked here, and not the error term as in an impulse response analysis. The author will supply, upon request, generalised impulse response (GIR) functions constructed for the LMRSTR and linear ARDL equations based on Koop, Pesaran and Potter (1996).
\[ E(\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}}) \] is also estimated by

\[
(\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}}) = \frac{\sum_{t=(\text{trimup}+p)}^{(T-h \max)} (\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}})}{(T - h \max - \text{trimup} - p + 1)}; \quad r = 0, 1, \ldots, h \max
\]

When \((T-h \max-\text{trimup}-p+1) \to \infty\), \((\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{shocked}}) \to E(\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{shocked}})\) and \((\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}}) \to E(\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}})\) by the law of large numbers. A consistent estimate of the simulated inflation response \((SIR_{t+r})\) is thus\(^{12}\)

\[
\widehat{SIR}_{t+r} = (\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{shocked}}) - (\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}})
\]

Conditional simulated inflation response \((\text{CondSIR}_{t+r})\), i.e. simulated inflation response conditional on a given history \((H)\) is also constructed, as follows

\[
\text{CondSIR}_{t+r} = (\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{shocked}}) - (\Delta y_{t+r}/I_{t-1}, X_{t+h \max}^{\text{historical}}); \quad t \in H
\]

The conditional simulated inflation response \((\text{CondSIR}_{t+r})\) is computed for the LMRSTR equation, where the simulated inflation response is history dependent, in addition to being non-proportional and asymmetric. For the linear ARDL equation, the simulated inflation response is not only proportional and symmetric, but also history independent such that the simulated inflation response \((SIR_{t+r})\) and the conditional simulated inflation response \((\text{CondSIR}_{t+r})\) are the same. These flexible features of the LMRSTR model are likely to make it more appealing to policy-makers than the conventional ARDL model.

\(^{12}\)An examination of the frequency distribution of the \(SIR\) for every horizon may be necessary, especially if there is multi-modality. However, this is beyond the scope of the present paper.
4. Empirical Findings

4.1 The Data

The raw data have been obtained from the Bank of Mauritius and consist of 312 monthly observations over the period January 1976 - December 2001 on the consumer price index (CPI), the Rs./$ monthly average exchange rate and the aggregate monetary resources (AMR).\textsuperscript{13}

The 25-year period under consideration has witnessed a number of important changes in the economic structure and policies of Mauritius. The country has gradually evolved from a monocrop sugar economy to a diversified economic system where the main pillars are nowadays sugar, textiles, tourism and financial services. A top priority of the authorities nowadays is to establish the country as a cyber-island where computer and information technologies would become the fifth pillar. With regard to monetary policy, Mauritius has smoothly shifted away from a framework of quantitative controls and administered rates to a market-based system. Liquidity management is nowadays performed through an active treasury bills market and a repo market, and exchange rates have been liberalised since July 1994. This highly-condensed summary, though being far from comprehensive, is outlined to show that Mauritius has gone through a number of economic regimes over the last 25 years. Hence the motivation to adopt a smooth and continuous regime-switching approach in this paper to model Mauritian inflation.

For modelling purposes, the raw time series are converted to natural logarithm and redefined as:

\[ p_t : \text{natural logarithm of the CPI} \]

\[ e_t : \text{natural logarithm of the Rs./$ exchange rate} \]

\textsuperscript{13}The CPI series, computed by the Central Statistical Office, uses as base period July 1996 - June 1997. The Rs./$ exchange rate is based on the average selling rate for telegraphic transfers and demand drafts. Aggregate Monetary Resources is the measure of broad money for Mauritius and is the sum of currency with the public, demand deposits, time and savings deposits and foreign currency deposits.
\( m_t \): natural logarithm of the aggregate monetary resources

Growth rate variables appearing in the estimated equations are all annualised. For example, monthly inflation is annualised as \([12 \ast (p_t - p_{t-1})]\).\(^{14}\)

### 4.2 The ARDL model

The ARDL equation (2) is estimated with \( y_t = p_t, x_t = [e_t \ m_t] \) and \( z_t \) containing a constant and monthly dummy variables over the period January 1978 - December 2001.\(^{15}\) Table 1 presents various lag selection criteria for the ARDL equation. The model is estimated with the lag order \( (p) \) ranging from 1 to 12, and the selected lag order is the minimum value of \( p \) which, based on the Godfrey test, implies no residual autocorrelation of order 1 to 12. A lag order of 1 for the ARDL equation implies significant autocorrelation of order 1 to 12. A lag order of 2 leads to autocorrelation of order 1 and 2 at the 5% significance level, though higher order autocorrelation disappears. This is judged unsatisfactory. A lag order of 3, which comfortably passes the autocorrelation tests of order 1 to 12, is thus selected. The estimated ARDL model appears in Table 2 and explains 33\% of the variation in monthly inflation.

### 4.3 The LSTR model

The auxiliary equation (5) is applied to investigate the possibility of LSTR nonlinearity and parameter nonconstancy in the ARDL model. Table 3 contains test results where the annual inflation rate, the annual US dollar appreciation/depreciation vis-à-vis the Mauritian rupee, and the annual broad money growth rate (all lagged 1 to 12 months) are used as transition

\(^{14}\)Based on the ADF test, \( p_t, e_t \) and \( m_t \) are integrated of order 1. For a demonstration that the concepts of nonstationarity and nonlinearity are not inconsistent, see Skalin and Terasvirta (2002).

\(^{15}\)To enable a consistent comparison with the LSTR and LMRSTR models later in this paper, the initial 24 observations over the period January 1976 - December 1977 are deleted in estimating the ARDL model. For an explanation on the deletion of initial observations, refer back to footnote 9. Also, January is used as the base month for the dummy variables.
variables. The hypothesis of linearity is rejected for a number of transition variables at the 5% significance level. However, it is worth noting that while only the first 3 lags of the annual inflation and the first 2 lags of annual money growth are significant, all lags (except the second lag) of the annual rate of change in the exchange rate are significant. This indicates the importance of the Rs./$ exchange rate in the dynamics of Mauritian inflation.

The annual rate of change in the exchange rate one month ago ($\Delta_{12}e_{t-1}$) is selected as the transition variable for the LSTR model, as it produces the lowest p-value (see Terasvirta (1994) for details on selection of transition variable). The test result when using a normalised time trend as transition variable also implies that the parameters of the estimated ARDL equation are strongly nonconstant.

Using ($\Delta_{12}e_{t-1}$) as transition variable and starting values based on a 2-dimensional grid search for $\eta_g$ and $c_g$, the LSTR model (4) is estimated with the Gauss Newton algorithm. The estimated LSTR equation appears in Table 4. This model explains 53% of the variation in monthly inflation. The adjustment and location parameters are estimated at 4.686 and 0.024 respectively. Figure 1 and Figure 2, which plot the value of the LSTR transition function against the transition variable and time respectively, imply that Mauritian inflation dynamics have been fluctuating between the two regimes at a rather fast rate. Figure 2 further indicates that the dynamics have hardly centred on linearity, which corresponds to a transition function value of zero. Figure 3 plots the residuals of the ARDL and LSTR equations over time. Table 5 reports diagnostics for the LSTR model. The variance ratio, expressed as the ratio of the residual sum of squares of the LSTR equation to that of the ARDL equation, equals 0.70. The model passes ARCH tests of order 1 to 12 at the 5% significance level. However, the LSTR residuals strongly fail autocorrelation tests of order

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16 Annual difference, rather than monthly difference, is used to purge the transition variables of seasonal noise.
1 to 12. The Jarque Bera statistic of 352 reveals non-normality of these residuals, but such non-normality is likely to be due to outliers occurring in November 1979, August 1980 and September 1990. Remaining nonlinearity and parameter constancy in the LSTR equation are investigated using equation (7). Table 5 reveals strong evidence of remaining nonlinearity (most significant when $\Delta_{12}e_{t-4}$ is the transition variable) and parameter nonconstancy in the LSTR model.

4.4 The LMRSTR model

The LSTR equation, though constituting an improvement in fit over the linear ARDL equation, fails crucial diagnostic tests. The possibility of multiple regimes in Mauritian inflation dynamics is thus investigated. The LMRSTR model (6) is estimated using the Gauss Newton algorithm, with the transition variables $s_{gt} = \Delta_{12}e_{t-1}$ and $s_{ht} = \Delta_{12}e_{t-4}$, and with starting values based on a 4-dimensional grid search for $\nu_g, d_g, \nu_h$ and $d_h$. The estimated LMRSTR equation is presented in Table 6. This model accounts for 73% of the variation in monthly inflation. The adjustment parameters for the transition functions G and H are estimated at 23.43 and 4.14 respectively, implying that the inflation dynamics are more sensitive (in terms of regime transition) to the annual rate of change in the exchange rate one month ago as compared to four months ago. This is verified in Figures 4, 5, 6 and 7, which further show that the inflation dynamics have hardly centred on linearity, which corresponds to both transition functions simultaneously taking a value of zero. Figure 8 and Figure 9 plot the LMRSTR residuals over time together with the ARDL residuals and the LSTR residuals respectively. Table 7 reports diagnostics for the LMRSTR model. The variance ratio between the LMRSTR equation and the ARDL equation is 0.40. The model passes ARCH and autocorrelation tests of order 1 to 12 at the 5% significance level. Residual normality is still rejected, due to outliers occurring in August 1980 and September 1990, but the Jarque
Bera statistic is 69 compared to 352 for the LSTR model. The LMRSTR model also passes the parameter constancy test. There is indication of remaining nonlinearity, but extending the LMRSTR model is beyond the scope of the present paper. The estimated LMRSTR equation, which does pass a range of diagnostic tests, is here considered to be an acceptable model of inflation dynamics for Mauritius.

4.5 Simulation results

The simulated inflation response (SIR) path (11) is computed, based on the estimated LMRSTR and ARDL equations, following shocks of ±0.12, ±0.36 and ±0.72 to the Rs./$ exchange rate growth path over a maximum horizon of 48 months.\(^\text{17}\) A maximum horizon of 48 months (4 years) is here believed to be long enough to clearly indicate the effect of shocks to exogenous variables on the inflation path.\(^\text{18}\) This produces 238 initial shock periods, with the first initial shock period being March 1978 and the last initial shock period being December 1997. The inflation path is dynamically simulated, using the shocked and historical exchange rate paths, with respect to each initial shock period.\(^\text{19}\) This leads to 238 shocked-simulation paths and also to 238 historical-simulation paths over the maximum horizon of 48 months. Averages across the 238 initial shock periods are computed for horizon 0 – 48 for each simulation path. A plot of the difference in averages for corresponding horizons against the horizon is the simulated inflation response (SIR) path, which is expected to indicate the response of inflation following shocks to exogenous variables.

Figure 10 contains the SIR for the ARDL model following shocks of +0.12, +0.36 and

\(^\text{17}\)The shocks are expressed as annualised rates. For example, if the annualised historical appreciation of the dollar against the rupee is 0.25 in a given month, a shock of +0.36 would imply a simulated dollar appreciation of 0.61 in that month.

\(^\text{18}\)Too short a maximum horizon will not give enough information on the simulated inflation path and too long a maximum horizon will reduce the reliability of (11) as a consistent estimator, so a balance has to be achieved in the selection.

\(^\text{19}\)The error term is set to zero in the simulations.
+0.72 to the Rs./$ exchange rate growth path. The $SIRs$ display proportionality in that responses are exactly proportional to shocks. The inflation response at first rises and, with respect to the initial shock period, starts to fall after 6 months regardless of the magnitude of the exchange rate shock. The ARDL model, which suffers from ommitted nonlinearity and parameter constancy, suggests that a dollar appreciation shock has a permanent effect on Mauritian inflation. Figure 12 further shows that the ARDL $SIRs$ for a dollar appreciation shock and a dollar depreciation shock are perfectly symmetric.

A completely different picture emerges with the LMRSTR model. Figure 11 shows that inflation responses are clearly non-proportional. As expected, the inflation effect at first rises for all 3 shock magnitudes. However, with respect to the initial shock period, the inflation response starts to fall after 7 months when the shock is +0.12, after 4 months when the shock is +0.36 and after 3 months when the shock is +0.72. This indicates that the higher the magnitude of the dollar appreciation, the sooner the inflation response starts to fall. The LMRSTR model also implies that, whatever the magnitude of the dollar appreciation, the inflation response is close to zero (below 1% on an annual basis) after 20 months.\footnote{Whether 20 months constitutes a reasonable or an acceptable time frame for the realignment of Mauritian inflation in response to an appreciating US dollar is an issue for debate.} This shows that, though explicit inflation targeting dates back to 1997/98 in Mauritius, the monetary authorities have all the way since 1976 paid due attention to the inflation rate. The LMRSTR model shows that a high enough dollar appreciation can even lead to a disinflationary response after some time. Figure 13 shows that the LMRSTR $SIRs$ are asymmetric. A dollar appreciation maximises the inflationary response after 6 months whereas a dollar depreciation maximises the disinflationary response after 15 months. This points to the monetary authorities having an asymmetric loss function where positive inflation deviations are penalised more severely than negative inflation deviations. Figure
14 contains the SIRs, conditional on exchange rate history prior to the initial shock period, following a shock of $+0.72$ to the Rs./$ exchange rate growth path. $SIR_{h5}$ is the SIR conditional on the dollar appreciating (on an annual basis) against the rupee in the 3 months preceding the initial shock period; there are 143 such histories in the sample. $SIR_{h6}$ is the SIR conditional on the dollar depreciating (on an annual basis) against the rupee in the 3 months preceding the initial shock period; there are 66 such histories in the sample. These conditional SIRs reveal rather different inflation response profiles.

5. Conclusions

The present paper shows that inflation dynamics for Mauritius contain significant nonlinearity and asymmetry. A linear ARDL specification, which has so far been the conventional approach to the modelling of inflation dynamics for developing countries, is shown to be inadequate for Mauritius. A two-regime LSTR model, with the annual rate of change in the Rs./$ exchange rate one month ago as transition variable, is estimated and found to constitute a significant improvement in fit over the ARDL model. However, the LSTR model fails a number of crucial diagnostic tests and is thus not satisfactory. A four-regime LMRSTR model, with the annual rate of change in the Rs./$ exchange rate one month ago and four months ago as transition variables, is then estimated. This multiple-regime model passes a range of diagnostic tests and constitutes a marked improvement over the two-regime LSTR model and hence the linear ARDL model. The LMRSTR model is thus our preferred model of Mauritius inflation dynamics. The dynamics of the LMRSTR equation and those of the conventionally adopted ARDL equation are investigated with a simulation exercise, whereby the response of inflation following shocks to the Rs./$ exchange rate path is obtained. The LMRSTR equation, unlike the ARDL equation, produces realistic inflation responses con-
firming that the inflation rate has all the way since 1976 been closely monitored by the monetary authorities of Mauritius. The LMRSTR equation, again unlike the ARDL equation, further shows that the inflation responses following an appreciation and a depreciation of the same magnitude of the US dollar are asymmetric. Finally, the LMRSTR also shows that the inflation response to a shock is dependent on the history of events preceding the shock.
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