Policy Uncertainty and the Demand for Money in Australia: An Asymmetry Analysis

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ABSTRACT

Previous research considered impacts of monetary and output uncertainty on the demand for money in Australia using a linear model and found that while output volatility has significantly positive effects, money supply volatility does not. Furthermore, predictive power of the linear model was very low. In this paper we use a nonlinear model and a new measure of uncertainty known as policy uncertainty and show that this new measure has significantly long-run asymmetric effects on the demand for money in Australia. Due to nonlinear adjustment of policy uncertainty measure, the new nonlinear model has a very high predictive power. The adjusted R^2 moves from 0.30 in the linear model to 0.80 in the nonlinear model.

JEL Classifications: E41

Key Words: Money Demand, Australia, Policy Uncertainty, Asymmetry, Nonlinear ARDL.

I. Introduction

In 1979 when the Fed switched its policy from fixing interest rates to targeting monetary aggregates, it missed its inflation target. Many attributed this failure to the failure of monetarist model of quantity theory of money. Friedman (1984) then argued that failure to achieve the inflation target was not due to failure of quantity theory, but rather due to volatility of money supply. He argued that money supply volatility could affect velocity of money and disturb the quantity theory of money. The implication is that the volatility of money supply could be a determinant of velocity or the demand for money, since velocity represents the linear combination of quantity of money supplied (or demanded at equilibrium), price level, and the level of output. If monetary volatility or monetary uncertainty can affect the demand for money, why not output volatility or uncertainty. Indeed, Choi and Oh (2003) presented a theoretical model that shows, indeed, output volatility can also affect the demand for money. These two uncertainty measures are said to affect public's decision to hold more or less money, depending on their expectations. If public expect high rate of inflation due to any uncertainty measure, they will hedge against it by holding more real assets and less cash. However, if they associate output and money volatility with uncertain future in terms of job prospects, they will hold more cash today.

The literature on the demand for money is so large that each country has its own literature and our country of concern, Australia is no exception. Studies that have estimated the demand for money and have tried to establish its stability are: Karfakis and Parikh (1993), Haque and Al-Mutairi (1996), Felmingham and Zhand (2001), Bahmani-Oskooee and Chomsisengphet (2002), and Valadkhani (2005). These studies have estimated the demand for different monetary aggregate using data from different periods without including any measure of monetary and output uncertainty. After reviewing these studies in detail, Bahmani-Oskooee and Xi (2011) included the two uncertainty measures in their specification and showed that the estimation results depend on how uncertainty measures are constructed.

Clearly, uncertainty introduced in the economy is not just due to volatility of money supply or real output. Today, perhaps, terrorism and political disputes create a more uncertain environment than anything else. Therefore, a more comprehensive measure of uncertainty should be the one that includes changes in macro policies such as money supply, output, taxes, spending, regulations, etc. Indeed, such measure is constructed by Economic Uncertainty Group for many countries including Australia.[1] The measure is known as measure of policy uncertainty and to construct it the Group searches for such terms as "policy", "tax", "spending", "regulation", "central bank", "budget", "uncertain", "uncertainty", "deficit", etc. from as many news papers as possible in each country and then a normalized index of the volume of news articles is constructed. While one news outlet may discuss a specific aspect of uncertainty by one policy, another outlet may discuss another aspect. The higher such discussions assoctaed with different uncertainty factor, the higher the importance of the news and the larger the "policy uncertainty" measure. In order to see how this new measure performs over time in Australia, we plot the measure in Figure 1.

Figure 1 goes about here

Our goal in this paper are two folds: First, how responsive is the demand for money in Australia to the new measure of policy uncertainty. Second, is the elasticity of money demand with regards to policy uncertainty the same for an increase in uncertainty as compared to a decrease in uncertainty, i.e., does policy uncertainty have symmetric or asymmetric effects on the demand for money in Australia. To this end, in Section II we introduce the models and methods. The results are reported in Section III. While Section IV concludes the paper, data sources and definition of variables are cited in an Appendix.

[1] See Economic Uncertainty Policy Group: http://www.policyuncertainty.com/europe_monthly.html

II. The Models and Methods

In formulating the demand for money in any country, it is a common practice to include a scale variable such as a measure of real income (Y) to account for transaction demand for money and interest rate (R) as a measure of opportunity cost of holding money. Furthermore, to account for currency substitution, the nominal effective exchange rate (EX) is also included. Finally, to assess the impact of policy uncertainty (PU), we add it to our specification. Thus, we begin with the following long-run demand for money in Australia:

$$LnM_t = a + bLnY_t + cLnR_t + dLnEX_t + eLnPU_t + \varepsilon_t \qquad (1)$$

where M is the quantity of money demanded. Following conventional wisdom, we expect an estimate of b to positive and that of c to be negative. As for the effects of exchange rate changes, while the original conjecture and idea belongs to Mundell (1963), Arango and Nadiri (1980) argued that a depreciation, i.e., a decline in EX variable, raises domestic currency value of foreign assets. If this increase is perceived as an increase in wealth, then the demand for domestic money will increase yielding a positive estimate of d. On the other hand, Bahmani-Oskooee and Pourheydarian (1992) argued that as domestic currency depreciates, if public expect further depreciation, they may hold more of foreign currency and less of domestic currency, thus, a positive estimate for d. Finally, as discussed in the previous section, policy uncertainty could have negative or positive impact on the demand for money depending on public's expectation.

Coefficient estimates of (1) by any method are long-run estimates. In order to infer short-run effects, we incorporate short-run dynamics by specifying (1) in an error-correction format. Since some variables such as policy uncertainty measure could be stationary or integrated of order zero, I(0), and some like income could be integrated of order one, I(1), an approach in which variables could be combination of I(0) and I(1) is that of Pesaran *et al.* (2001) as outlined by (2) below:

$$\Delta LnM_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnM_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnY_{t-i} + \sum_{i=0}^{n3} \phi_i \Delta LnR_{t-i} + \sum_{i=0}^{n4} \eta_i \Delta LnEX_{t-i}$$
$$+ \sum_{i=0}^{n5} \lambda_i \Delta LnPU_{t-i} + \rho_0 LnM_{t-1} + \rho_1 LnY_{t-1} + \rho_2 LnR_{t-1} + \rho_3 LnEX_{t-1}$$
$$+ \rho_4 LnPU_{t-1} + \mu_t \qquad (2)$$

Specification (2) follows Engle and Granger (1987) where rather than including lagged value of the error term from (1) in (2), Pesaran *et al.* (2001) included linear combination of lagged level variables which is equal to ε_{t-1} by deduction. They then recommend applying the F test to establish joint significance of lagged level variables as a sign of cointegration. They tabulate new critical values for this F test that account for integrating properties of variables.[2] Once cointegration is established, estimates of ρ_1- ρ_4 normalized on ρ_0 reflect long-run effects and coefficient estimates attached to first-differenced variables reflect short-run effects.

One main assumption in (1) or (2) is that impact of policy uncertainty on the demand for money is symmetric. However, this need not be the case. Assume 5% increase in uncertainty measure induces public to reduce their cash holding by 10%. Decreased uncertainty by 5% may induce public to hold cash by less than 10% because due to less uncertain environment, they could allocate their portfolio towards more real assets or other financial assets. The asymmetric effects of policy uncertainty measure could also be due to change in public's expectation. Assume public hold less cash due to an uncertain environment for some time. Even if uncertainty is reduced in the following period, public still may hold less cash and more real assets if they expect additional increased uncertainty in the following period. In order to assess the asymmetric effects of policy uncertainty measure, we follow Shin *et al*. (2014) and form *ΔLnPU* which includes positive as well as negative changes. From this series, we use the concept of partial sum and generate two new time-

[2] Indeed, variables could be combination of I(0) and I(1) and this is one the main advantages of this approach.

series variables as:

$$POS_t = \sum_{j=1}^{t} \Delta LnPU_j^+ = \sum_{j=1}^{t} \max(\Delta LnPU_j, 0),$$

$$NEG_t = \sum_{j=1}^{t} \Delta LnPU_j^- = \sum_{j=1}^{t} \min(\Delta LnPU_j, 0) \qquad (3)$$

In (3) the POS variable which is the partial sum of positive changes reflects only increased policy uncertainty. Similarly, the NEG variable which is the partial sum of negative changes reflects only decreased policy uncertainty. We then go back to error-correction model (2) and replace *LnPU* variables by POS and NEG variables to arrive at:

$$\Delta LnM_t = \alpha + \sum_{i=1}^{n1} \beta_i \Delta LnM_{t-i} + \sum_{i=0}^{n2} \delta_i \Delta LnY_{t-i} + \sum_{i=0}^{n3} \phi_i \Delta LnR_{t-i} + \sum_{i=0}^{n4} \eta_i \Delta LnEX_{t-i}$$

$$+ \sum_{i=0}^{n5} \lambda_i^+ \Delta POS_{t-i} + \sum_{i=0}^{n6} \lambda_i^- \Delta NEG_{t-i} + \rho_0 LnM_{t-1} + \rho_1 LnY_{t-1} + \rho_2 LnR_{t-1}$$

$$+ \rho_3 LnEX_{t-1} + \rho_4^+ POS_{t-1} + \rho_4^- NEG_{t-1} + \mu_t \qquad (4)$$

Due to method of constructing the POS and NEG variables, Shin *et al.* (2014) call specification (3), a nonlinear ARDL model while (2) is labeled the linear ARDL model. They then demonstrate that Pesaran *et al.*'s bounds testing approach is equally applicable to (4). Furthermore, they argue due to dependency between the two partial sum variables, they should be treated as a single variable in (4) so that when we move from (2) to (4) critical values of the F test stay the same.[3]

Once (4) is estimated by the OLS method using a set criterion, a few asymmetry hypothesis could be tested. First, policy uncertainty could have short-run asymmetric effects on the demand for money if at each lag estimate of λ^+ is different than estimate of λ^-. Second, if number of optimum lags on ΔPOS is different than number of lags on ΔNEG, that will be an indication of adjustment asymmetry. Third, we will establish short-run cumulative or impact asymmetry if $\sum \lambda_i^+ \neq \sum \lambda_i^-$.

[3] See Shin et al. (2014, p. 291).

Finally, long-run asymmetric effects of policy uncertainty will be established if estimates of $-\frac{\rho_4^+}{\rho_3} \neq -\frac{\rho_4^-}{\rho_3}$. To establish the last two inequalities, the Wald test is the recommended test.[4]

III. The Results

In this section we try to estimate both the linear and nonlinear ARDL models outlined by equations (2) and (4) respectively, using quarterly data over the period 1998II-2016II. This study period is determined by the availability of data, especially the measure of policy uncertainty which is only available from 1998II onward. In estimating either model, since data are quarterly, we imposed a maximum of eight lags and used Akaike's Information Criterion (AIC) to select an optimum model. Since different statistics and estimates have different critical values, we collect these values in the notes to each table and use them to identify estimates and statistics by * if they are significant at the 10% level and by ** if they are significant at the 5% level. However, before presenting the results, we report some descriptive statistics in Table 1

Table 1 goes about here

In Table 1 not only we report descriptive statistics for each variable, but also we report the unit root test results by applying the well-known ADF test to the level and first differenced variables. As can be seen, all variables are first-differenced stationary, I(1), except the policy uncertainty measure which is stationary or I(0). Indeed, this justifies using the ARDL models which require variables to be combination of I(0) and I(1) but not I(2). Next we report estimate of each optimum linear and nonlinear ARDL model in Table 2.

[4] For some other application of these methods in recent literature see Gogas and Pragidis (2015), Durmaz (2015), Baghestani and Kherfi (2015), Al-Shayeb and Hatemi-J.(2016), Lima et al. (2016), Bahmani-Oskooee and Mohammadian (2016), Bahmani-Oskooee and Fariditavana (2016), Aftab et al. (2017), Arize et al. (2017), and Gregoriou (2017).

Table 2 goes about here

There are two sections in Table 2. While Section I reports the estimates of the linear ARDL model, Section II does the same for nonlinear ARDL model. Also, there are three panels in each section. While Panel A reports short-run coefficient estimates, Panel B reports the long-run normalized coefficient estimates. Finally, all diagnostics are reported in Panel C. From the short-run estimates of the linear model we gather that every variable carries at least one significant lagged estimate, implying that all four variables do have short-run effects on the demand for money in Australia. However, short-run effects does not last into the long run, since in Panel B no variable carries significant coefficient estimate. If we were to rely upon the old approach of estimating only the linear model, the process would have stopped right here and we would have concluded that our new variable, i.e., a measure of policy uncertainty has no long-run effects on the demand for money in Australia during our study period. However, when we shift to estimates of the nonlinear model in Sections II, we observe that not only all variables do have short-run effects, but also the short-run effects of all variables do last into the long run. The long-run estimates in Panel B of Section II reveal that all normalized long-run estimates are significant and carry their expected signs. Income elasticity is positive and highly significant and interest rate elasticity is negative and highly significant. The nominal effective exchange rate carries a significantly positive coefficient, implying that as Australian dollar depreciates, Australians hold less of domestic currency and more of foreign currency.[5]

As for the effects of policy uncertainty measure, it appear that both partial sum variables, i.e., POS and NEG carry significantly positive coefficient estimates, implying that increased uncertainty will induce public to hold more domestic currency and decreased uncertainty will induce them to hold less domestic currency. These elasticities are significantly different from each

[5] This finding is in line with Bahmani-Oskooee and Xi (2011).

other in size, as reflected by significant Wald statistic reported as Wald-L in Panel C. Therefore, in Australia policy uncertainty seems to have long-run asymmetric effects on the demand for money. Furthermore, these long-run asymmetric effects as well as long-run effects of other variables are valid since cointgeration is supported by the F test as well as ECM_{t-1} test. The latter test is an alternative test for cointgeration where we use the long-run normalized coefficient estimates and long-run money demand function and generate the error term, called ECM_{t-1}.[6] We then replace the linear combination of lagged level variables in (4) by ECM_{t-1} and estimate the new specification after imposing the same optimum lag structure. Cointegration is supported if ECM_{t-1} carries a significantly negative estimate. Clearly, this is the case in Panel C, reinforcing cointegration in the nonlinear model.[7]

A few other statistics are also reported in Panel C. To test for serial correlation, we report the Lagrange Multiplier statistic as LM. Since it is insignificant, residuals are autocorrelation free. We have also reported size of adjusted R^2 to judge good ness of fit. As can be seen the nonlinear model yields a much higher adjusted R^2 than the linear model, supporting nonlinear adjustment of the policy uncertainty variable. It is also a common practice to establish stability of the coefficient estimates. Following the literature, we apply the CUSUM and CUSUMSQ test. Clearly, all estimates are stable as indicated in Panel C. We have also reported the Wald-S to determine if there is evidence of short-run cumulative asymmetric effects of policy uncertainty. Since the Wald-S statistic is insignificant, we do not have evidence of short-run cumulative asymmetric effects. However, from the short-run coefficient estimates we gather that at each specific lag, ΔPOS carries

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[6] Note that in the nonlinear model, the long-run demand for money is specified as:

$$LnM_t = a + bLnY_t + cLnR_t + dLnEX_t + ePOS_t + fNEG_t + \varepsilon_t.$$

[7] Note that this ECM_{t-1} test was introduced by Banerjee et al. (1998) within Engle-Granger cointegration framework where variables should all be I(1). Within ARDL approach where variables are combination of I(0) and I(1), Pesaran et al (2001, p. 303) tabulate new upper and lower bound critical values for the t-test. See notes to Table 2. Note also that the estimated coefficient in the nonlinear model is much higher than the linear model, implying introducing nonlinear adjustment has increased the speed of adjustment to 1.69 or to 85% within six weeks.

a different coefficient estimate than ΔNEG, supporting short-run asymmetric effects.

To engage in some sensitivity analysis, we change the threshold level in constructing the partial sum variables from zero to 2 and ask if an increase in the measure of policy uncertainty more than 2% still has asymmetric effects on the demand for money compared to a decline in the measure of policy uncertainty that is less than 2% as outlined by (5) below:

$$POS_t = \sum_{j=1}^{t} \Delta LnPU_j^+ = \sum_{j=1}^{t} \max(\Delta LnPU_j, 0.02),$$

$$NEG_t = \sum_{j=1}^{t} \Delta LnPU_j^- = \sum_{j=1}^{t} \min(\Delta LnPU_j, 0.02) \qquad (5)$$

The results are reported in Table 3 and as can be seen, there is no change in our previous conclusion that increased uncertainty increases the demand for money in Australia and decreased uncertainty reduces the demand for money, but in an asymmetric manner. Indeed, long-run elasticity is higher for reduced policy uncertainty measure.

Table 3 goes here

IV. Concluding Remarks

In addition to being concerned about stability of the demand for money, researchers have tried to identify its main determinants in order to better formulate monetary policy. Measures of money and output volatility are two uncertainty measures that have been identified by previous research to affect the demand for money. Increase in any of the two uncertainty measures could have positive or negative impact on the demand for money. On the one hand, increased uncertainty could induce people to hold more cash today in order to cover themselves in the future. On the other hand, if they perceive any uncertainty to result in an inflationary environment, they may hold less cash and more real assets to hedge against inflation.

However, volatility of money supply and output are not the only variables that introduce uncertainty into economic environment. Changes in political regimes, regulations, taxes, budgets, trade deals, etc. all contribute to an uncertain environment. To incorporate all these factors in a single measure of uncertainty, the Economic Policy Uncertainty Group has introduced a relatively more comprehensive measure of uncertainty in many developed countries known as "Policy Uncertainty". In each country they search as many newspapers as possible for such words as "policy", "tax", "spending", "regulation", "central bank", "budget", "uncertain", uncertainty", "deficit", etc. From this search every month, they construct a normalized index of the volume of news articles as a measure of policy uncertainty.

Previous research assessed the impact of monetary and output volatility or uncertainty on the demand for money in Australia using a linear model and found that while output uncertainty has significantly positive long-run effects, monetary undertainty does not. Furthermore, the size of adjusted R^2 was very low (0.28) which reduces predictive power of estimates. In this paper, we use the newlly constructed ploicy uncertainty measure in order to assess the impact of policy uncertainty on the demand for money in Australia. In addition to using the linear ARDL model like previous research, we also use the nonlinear ARDL model which helps us to determine if effects of policy uncertainty are asymmetric. Indeed, the results reveal that measure of policy uncertainty has significant asymmetric effects on the demand for money in Australia. Decreased policy uncertainty reduces the demand for cash in Australia and increased uncertainty increases it, but at different rates. Furthermore, the adjusted R^2 in this newelly specified nonlinear model was more than 0.80, which makes nonlinear model more attractive than the linear model.

APPENDIX
Data Definition and Sources

Quarterly data over the period 1998 II -2016 II are used to carry out the estimation. The main restriction for using data prior to 1998 is unavailability of data on policy uncertainty. Data are collected from the following sources:

(a) International Financial Statistics (IFS) of International Monetary Fund (IMF).
(b) Economic Policy Uncertainty Group:
http:// www.policyuncertainty.com/europe_monthly.html

Variables:

M3 = Money supply measured by real M3. Nominal M3 figures are deflated by GDP deflator. Data come from Source (a).

Y = Nominal GDP is deflated by GDP deflator to arrive at real GDP (2010 = 100). Data come from Source (a).

R = Interest rate. Money market rates come from Source (a).

EX = Index of nominal effective exchange rate of the Australian dollar. A decline reflects a depreciation of Australian dollar. Data come from Source (a).

PU = policy uncertainty measure. Data come from Source (b).

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Figure 1: Plot of Policy Uncertainty Measure for Australia

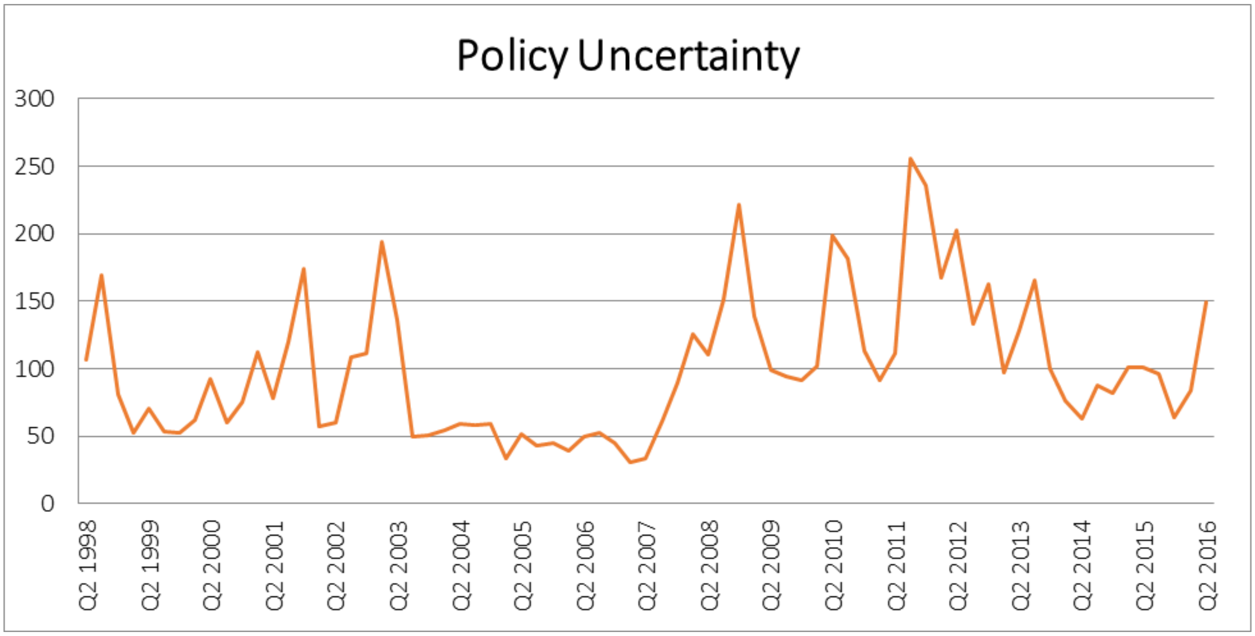

Table 1: Summary Statistics for All Variables

	Variables				
	M	Y	R	EX	PU
Mean	10813.98	91.57658	4.532192	89.88082	99.22559
Min	6864.255	67.19000	1.840000	70.85000	30.34399
Max	17935.12	116.5100	7.250000	111.5200	255.6716
Std Dev	3305.676	14.21798	1.374434	11.54685	51.80383
Skewness	0.576228	0.013137	-0.296578	0.137966	1.042959
Kurtosis	1.985467	1.787993	2.339733	2.111218	3.522974

Augmented Dickey-Fuller test

		Variables				
		Ln M	Ln Y	Ln R	Ln EX	Ln PU
With Constant	Level	0.88(0)	-2.24(0)	-0.19(2)	-1.74(1)	-3.36(0)**
	First Difference	-4.61(1)**	-7.24(0)**	-5.16(1)**	-6.18(1)**	-6.38(3)**
With Constant and Trend	Level	-1.42(0)	-2.56(0)	-1.66(2)	-2.50(1)	-3.51(0)**
	First Difference	-7.71(0)**	-6.54(2)**	-5.38(1)**	-6.16(1)**	-6.31(3)**

Notes: Real money supply (M) IS in Millions of Australian Dollar.
Std Dev is standard deviation. * and ** denote statistical significance at the 10% and 5% confidence levels, respectively. Number inside the parenthesis is the number of lags selected by AIC.

Table 2: Full-information estimates of Both Linear and Nonlinear Models

I. **Linear ARDL Model**								
	Panel A: short-run coefficient estimates							
Lag order	0	1	2	3	4	5	6	7
ΔLnM	-							
ΔLnY	-1.35*	2.48**	-0.41	-2.82**	2.18**	-1.42	1.83**	
	(2.10)	(2.74)	(0.44)	(3.06)	(2.33)	(1.52)	(2.89)	
ΔLnR	-0.007	0.48**	-0.49**	0.21**				
	(0.12)	(3.59)	(4.27)	(3.80)				
ΔLnLEX	-0.15**							
	(2.40)							
ΔLnPU	-0.017	-0.0002	0.005	-0.03**				
	(1.94)	(0.02)	(0.46)	(3.27)				
	Panel B: long-run coefficient estimates							
Constant	LnY	LnR	LnEX	LnPU				
-21.29	15.44	2.56	-7.22	0.53				
(-0.30)	(0.58)	(0.49)	(0.50)	(0.49)				
	Panel C: Diagnostics							
F	ECM_{t-1}	LM	$\bar{R}^2$	CUSUM	CUSUMQ			
5.188**	-0.02	1.23	0.50	Stable	Stable			
	(0.55)							

II. **Non-linear ARDL Model**								
	Panel A: short-run coefficient estimates							
Lag order	0	1	2	3	4	5	6	7
ΔLnM	-	1.12**	0.69**	0.77**	0.97**	1.19**	0.53	0.32
		(4.32)	(4.85)	(4.00)	(3.73)	(4.18)	(2.07)	(1.69)
ΔLnY	0.57	0.48	-1.88	-3.06**	2.44*	-0.76		
	(0.83)	(0.46)	(1.87)	(3.35)	(2.32)	(1.15)		
ΔLnR	0.02	0.30	-0.18	0.02	0.27	-0.13	0.24	0.19*
	(0.30)	(2.02)	(1.28)	(0.18)	(1.87)	(0.81)	(1.57)	(2.16)
ΔLnLEX	-0.17	0.22	0.26	-0.13	0.016	-0.48**	-0.13	-0.44**
	(1.09)	(1.886)	(1.98)	(0.80)	(0.11)	(3.28)	(0.81)	(3.12)
ΔPOS	-0.0004	0.007	0.04	0.02	-0.06**	0.02	-0.03	-0.05**
	(0.02)	(0.29)	(1.70)	(0.91)	(2.77)	(0.93)	(1.23)	(2.88)
ΔNEG	0.08**	-0.12**	-0.04	0.05*	-0.05**	-0.04	-0.03	
	(4.16)	(3.77)	(2.00)	(2.38)	(2.7)	(1.89)	(1.61)	
	Panel B: long-run coefficient estimates							
Constant	LnY	LnR	LnEX	POS	NEG			
3.43	4.48**	-0.34**	0.22**	0.11**	0.28**			
(1.78)	(9.57)	(9.64)	(4.43)	(4.14)	(24.25)			
	Panel C: Diagnostics							
F	ECM_{t-1}	LM	$\bar{R}^2$	CUSUM	CUSUMQ	Wald-L	Wald-S	
6.56**	-1.69**	2.47	0.83	Stable	Stable	39.02**	0.55	
	(4.99)							

Notes:

a. Numbers inside the parentheses are absolute value of t-ratios. *, ** indicate significance at the 10% and 5% levels respectively.

b. The upper bound critical value of the F-test for cointegration when there are four exogenous variables is 3.52 (4.01) at the 10% (5%) level of significance. These come from Pesaran *et al*. (2001, Table CI, Case III, p. 300).

c. The critical value for significance of ECM_{t-1} is -3.66 (-3.99) at the 10% (5%) level when k =4. The comparable figures when k = 5 in the nonlinear model are -3.86 and -4.19 respectively. These come from Pesaran *et al*. (2001, Table CII, Case III, p. 303).

d. LM is the Lagrange Multiplier statistic to test for autocorrelation. It is distributed as χ^2 with 1 degree of freedom. The critical value is 2.70 (3.84) at the 10% (5%) significance level.

e. Both Wald tests are also distributed as χ^2 with one degree of freedom. The critical value is 2.70 (3.84) at the 10% (5%) significance level.

Table 3: Full-information Estimate of Nonlinear Model with 2% Threshold

Panel A: short-run coefficient estimates

Lag order	0	1	2	3	4	5	6	7
ΔLnM	-	1.22**	0.65**	0.85**	1.09**	1.27**	0.57	0.35
		(4.39)	(3.40)	(4.06)	(3.77)	(4.04)	(2.08)	(1.71)
ΔLnY	0.22	0.51	-2.29	-2.72**	2.99**	-1.31	0.75	
	(0.28)	(0.45)	(1.99)	(2.81)	(2.56)	(1.17)	(0.93)	
ΔLnR	0.04	0.36	-0.19	0.07	0.21	-0.16	0.34	0.16
	(0.59)	(2.15)	(1.31)	(0.48)	(1.33)	(0.93)	(1.90)	(1.58)
ΔLnLEX	-0.24	0.24	0.18	-0.08	0.06	-0.51**	-0.19	-0.47**
	(1.38)	(1.92)	(1.22)	(0.45)	(0.40)	(3.21)	(1.14)	(3.29)
ΔPOS	-0.001	0.006	-0.52	0.01	-0.07**	0.03	-0.04	-0.06**
	(0.08)	(0.26)	(1.85)	(0.55)	(2.74)	(1.33)	(1.53)	(3.03)
ΔNEG	0.07**	-0.13**	-0.04	-0.05*	-0.05**	-0.04	-0.03	0.01
	(3.76)	(3.85)	(2.05)	(2.53)	(2.91)	(2.14)	(1.62)	(0.81)

Panel B: long-run coefficient estimates

Constant	LnY	LnR	LnEX	POS	NEG
6.05**	3.75**	-0.31**	0.20**	0.12**	0.28**
(3.03)	(7.40)	(6.72)	(3.07)	(4.00)	(20.31)

Panel C: Diagnostics

F	ECM_{t-1}	LM	$\bar{R}^2$	CUSUM	CUSUMQ	Wald-L	Wald-S
6.55**	-1.75**	14.46**	0.83	Stable	Stable	36.36**	0.018
	(4.75)						

Notes:

a. Numbers inside the parentheses are absolute value of t-ratios. *, ** indicate significance at the 10% and 5% levels respectively.

b. The upper bound critical value of the F-test for cointegration when there are four exogenous variables is 3.52 (4.01) at the 10% (5%) level of significance. These come from Pesaran *et al*. (2001, Table CI, Case III, p. 300).

c. The critical value for significance of ECM_{t-1} is -3.66 (-3.99) at the 10% (5%) level when k =4. The comparable figures when k = 5 in the nonlinear model are -3.86 and -4.19 respectively. These come from Pesaran *et al*. (2001, Table CII, Case III, p. 303).

d. LM is the Lagrange Multiplier statistic to test for autocorrelation. It is distributed as χ^2 with 1 degree of freedom. The critical value is 2.70 (3.84) at the 10% (5%) significance level.

e. Both Wald tests are also distributed as χ^2 with one degree of freedom. The critical value is 2.70 (3.84) at the 10% (5%) significance level.