Asymmetric Effects of Economic Uncertainty on Money Demand Function in Bangladesh: A Nonlinear ARDL and Cumulative Fourier Causality Approach

S. M. Woahid Murad*

Department of Economics, Noakhali Science and Technology University, Noakhali, Bangladesh

Abstract

This study revisits the demand for money in Bangladesh considering economic uncertainty and covering 1999:M1 to 2018:M6. We employed a nonlinear ARDL model and cumulative Fourier causality tests. In contrast to the previous studies, we obtain higher exchange rate elasticity and lower income elasticity of money demand function. It is found that people hold less money in the short run when uncertainty increases, albeit it does not sustain in the long run. On the contrary, demand for money rises in the short run and declines in the long run when uncertainty decreases. We also find a unidirectional causality from income and economic uncertainty to money after considering the Fourier causality test. Therefore, a fiscal policy should be considered along with a monetary policy to tune Bangladesh's economy.

Keywords: Money Demand, Output Uncertainty, Nonlinear ARDL, Fourier Causality, Bangladesh

JEL Classification: C22, E41

* Correspondence to: Department of Economics, Noakhali Science and Technology University, Noakhali-3814, Bangladesh. Email: w.murad@nstu.edu.bd. The author is grateful to two anonymous reviewers of this journal for their valuable comments on an earlier draft of this paper. However, the usual disclaimer would be applied.

1. Introduction

The monetary policy of Bangladesh attempts to stabilize the price level and accelerate economic growth with job-supportive and eco-friendly strategies. However, stability of the money demand function is essential for the effectiveness of monetary policy (for instance, Friedman, 1956).

At the end of the 1970s, the US economy failed to attain the inflation target for three consecutive years. The quantity theory of money was highly criticized. Therefore, Friedman (1984) encompassed the volatility of money in his money demand function and explored the dominant role of monetary uncertainty in determining the demand for money. Later, Brüggemann and Nautz (1997) reinvestigated Friedman (1984) model in the context of Germany and found an inverse relationship between monetary uncertainty and demand for money. On the contrary, Choi and Oh (2003) developed a theoretical framework considering output uncertainty and monetary uncertainty together in the traditional money demand function. Using the U.S. data, they reported a negative effect of output uncertainty and a positive effect of monetary uncertainty on demand for money. It may happen since output uncertainty generates uncertain job prospects, and, therefore, people allocate their money in less volatile assets.

Moreover, several studies empirically examined the impact of output volatility on demand for money, for instance, Hall and Noble (1987), Bahmani-Oskooee and Xi (2011), Bahmani-Oskooee, Xi, and Wang (2012), Özdemir and Saygili (2013), Bahmani-Oskooee, Satawatananon, and Xi (2015), Bahmani-Oskooee and Arize (2020). However, the effect of macroeconomic volatility on demand for holding money varies substantially across countries. Therefore, a country-specific estimation of the money demand function is required to develop an effective monetary policy of that country.

An extensive number of studies estimated the money demand function for Bangladesh. For instance, Ahmed (1977), and Murti and Murti (1978) estimated the money demand function for Bangladesh considering real income and nominal interest rate, while Taslim (1984) chose expected inflation instead of interest rate, and they obtained a stable money demand function for Bangladesh. Besides, Ahmed (1999), Siddiki (2000), Hossain (2010) estimated Bangladesh's money demand function within an open economy framework. Ahmed (1999) considered the real exchange rate, while Siddiki (2000), Hossain (2010) regarded it as nominal exchange rate and nominal effective exchange rate, respectively. All of them found a significant effect of the exchange rate on demand for money. However, none of the prior empirical studies considered volatility or uncertainty in estimating the money demand function of Bangladesh. Consequently, this current study attempts to address the literature gap and examine the asymmetric effect of economic volatility on the money demand function of Bangladesh. Moreover, this study also explored the causal relationship among money, income, interest rate, exchange rate, and economic volatility using cumulative Fourier-frequency.

The rest of the paper's outline is as follows: Section 2 covers the model's specification, data sources, and methodology. Section 3 reports and discusses empirical findings, and finally, Section 4 provides concluding remarks of this study.

2. Model Specification, Data Sources, and Estimation Methods

As postulated in Keynes (1936), a traditional money demand function expresses demand for money as a function of income and interest rate. Afterward, Mundell (1963) and Choi and Oh (2003) augmented the money demand function by adding foreign exchange rate, output uncertainty, respectively. After considering all these improvements together and adding an error term, the following log-linear empirical model can be specified:

$$m_t = \beta_0 + \beta_1 y_t + \beta_2 i_t + \beta_3 s_t + \beta_4 vol_t + u_t, \quad (1)$$

where, β_0 = intercept, m = real money supply obtained from nominal M_2 deflated by the CPI, y = industrial production index (IPI) as a proxy of income, i = nominal interest rate obtained from the money market rate, s = real exchange rate of Bangladeshi taka against the US dollar, vol = economic volatility generated from the GARCH effect of the IPI, t = time, u is an error term and $u \approx N(0, \sigma)$. This study covers monthly data from 1999:M1 to 2018:M6. The starting and ending period is chosen based on the availability of data of the selected variables. Data is compiled from the Monthly Economic Trends published by the Bangladesh Bank and the International Financial Statistics published by the IMF. All of the variables are in the natural log.

According to the Keynesian and monetarists' hypotheses, β_1 is expected to be positive, implying that demand for money increases with income at the cost of foregone interest earnings. In contrast, the expected sign of β_2 is negative since the interest rate is considered as an opportunity of holding money. However, the signs of β_3 and β_4 are ambiguous. The coefficient of the real exchange rate depends on the relative strength of the wealth effect and substitution effect. During a depreciation of Bangladeshi taka, people are supposed to hold more cash if the wealth effect outweighs the substitution effect. Finally, the sign of β_4 depends on how people allocate their money during the uncertain prospect. However, recent empirical studies, for instance, Bahmani-Oskooee, Halicioglu and Bahmani (2017), Bahmani-Oskooee and Maki-Nayeri (2019), and Murad, Salim and Kibria (2021), found asymmetric effects of uncertainty on demand for holding money. For considering asymmetric effects of output uncertainty in Equation (1), we decompose the uncertainty in cumulative partial sum of positive and negative values of vol in the following way:

$$vol_t^+ = \sum_{i=1}^{t} \Delta vol_i^+ = \sum_{i=1}^{t} max(\Delta vol_i, 0),$$
$$vol_t^- = \sum_{i=1}^{t} \Delta vol_i^- = \sum_{i=1}^{t} min(\Delta vol, 0), \quad (2)$$

vol_t is replaced in Equation (1) by its cumulative partial sums as defined in Equation (2) to examine the asymmetric effect of volatility. To estimate the nonlinear ARDL model, Equation (1) can be restated in the following way:

$$\Delta m_t = \alpha + \sum_{i=1}^{a} \gamma_i \Delta m_{t-i} + \sum_{i=1}^{b} \eta_i \Delta y_{t-i} + \sum_{i=1}^{c} \lambda_i \Delta i_{t-i} + \sum_{i=1}^{d} \varphi_i \Delta s_{t-i} + \sum_{i=1}^{e} \omega_i^+ \Delta vol_{t-i}^+ + \sum_{i=1}^{f} \omega_i^- \Delta vol_{t-i}^- + \rho_0 m_{t-1} + \rho_1 y_{t-1} + \rho_2 i_{t-1} + \rho_3 s_{t-1} + \rho_4 vol_{t-1}^+ + \rho_5 vol_{t-1}^- + \varepsilon_t, \quad (3)$$

where Δ is the first difference operator; α is the drift term; a to f are the optimum lag lengths selected by the Akaike information criterion (AIC). γ, η, λ, φ, ω^+ and ω^- are the short-run parameters while the estimates of ρ_1 to ρ_5 present the long-run effects. The long-run estimates are normalized on ρ_0. Finally, ε_t is the white noise error term.

Before proceeding to estimate the short-run and long-run parameters, one should confirm that the variables are cointegrated. Pesaran, Shin, and Smith (2001) propose the bounds testing procedure to identify a cointegrating relationship among the variables. If the calculated F-statistic exceeds the critical values of the upper and lower bounds, one can conclude that the considered variables are cointegrated. Subsequently, Kripfganz and Schneider (2020) develop critical values for the bounds testing approach through response surface models. Therefore, we have considered both Pesaran, Shin, and Smith (2001) and Kripfganz and Schneider (2020) critical values to establish a cointegrating relationship among the variables.

A battery of diagnostic tests has been occupied to identify specification bias of the models. We employ the Breusch-Godfrey LM test, White homoscedasticity test, and Ramsey RESET test to check the presence of serial correlation, heteroscedasticity, and omitted variable bias problems, respectively. The skewness and kurtosis tests show the normality of the model. Finally, the Wald test statistics ensure the short-run and long-run asymmetry.

Furthermore, we incorporate the recently developed Fourier Toda-Yamamoto causality test with a cumulative frequency of Gormus, Nazlioglu, and Soytas (2019) (hereafter, GNS) along with Toda and Yamamoto (1995) causality test. These tests help to identify causal relationships among money, income, interest rate, real exchange rate, and volatility. These causality tests were incorporated to provide an insight into the Keynesian and monetarists' debate. More specifically, it will help in concluding the direction of causality between money and income.

Toda and Yamamoto (1995) postulated Granger causality test is based on the $VAR(p+d)$ model, which can be specified as follows

$$x_t = \theta + \sum_{i=1}^{p+d} \delta_i x_{t-i} + \nu_t, \tag{4}$$

where θ is an intercept vector, x is a vector of k endogenous variables, δ is a coefficient vector, p is the lag length and d is the maximum order of integration, t denotes time, and finally, ν is a vector of white noise residuals. Here the null hypothesis is based on zero restriction on p of the k^{th} y, i.e., $H_0: \delta_1 = \cdots = \delta_p = 0$. The Wald test statistic for this hypothesis test follows an asymptotic χ^2 distribution with p degrees of freedom.

To accommodate unknown smooth structural breaks, GNS (2019) utilizes a Fourier series approximation. Therefore, using Fourier functional form, Equation (4) can be expressed as

$$x_t = \theta_0 + \phi_1 \sin\left(\frac{2\pi kt}{T}\right) + \phi_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{p+d} \delta_i x_{t-i} + \nu_t, \tag{5}$$

where k stands for the approximation frequency, T presents the number of observations, ϕ_1 and ϕ_2 measure the amplitude and displacement of the frequency, respectively.

Equation (5) illustrates a Fourier Toda-Yamamoto causality test. However, according to GNS (2019), the Toda and Yamamoto causality test is suitable for a small sample size (for example, $T \cong 25$), while a single frequency Fourier Toda-Yamamoto causality test is appropriate for the sample size between 50 to 100. On the contrary, a cumulative frequency of the Fourier Toda-Yamamoto causality test yields precise estimations if the number of observations is around 250. Therefore, we have considered a cumulative frequency of the Fourier Toda-Yamamoto causality test in our study with the traditional Toda-Yamamoto causality test.

3. Empirical Findings

Like Pesaran, Shin, and Smith (2001) ARDL bounds testing approach, the nonlinear ARDL model required all the variables either $I(0)$ and/or $I(1)$. Table 1 reports the results of several unit root tests. Phillips and Perron (1988) test applied the Newey and West estimators to correct the potential serial correlation problem, while Rodrigues and Taylor (2012) Fourier GLS test considered nonlinearities and smooth structural breaks in a series. However, both unit root tests ensure that all variables are stationary after taking their first difference. Therefore, it provides a basis for the nonlinear ARDL test.

Table 1. Results from unit root tests

Variable	Phillips & Perron (1988) test		Rodrigues & Taylor (2012) Fourier GLS test		Narayan & Popp (2010) two breaks ADF test		
						Structural breaks	
	Level	1st Diff.	Level	1st Diff.	Level	1st break	2nd break
m	-2.586	-18.49***	-2.275	-6.94***	-5.36***	2007:02	2011:12
y	-8.23***	-27.91***	-5.057***	-9.227***	-4.274	2005:02	2009:05
i	-5.218***	-19.43***	-5.114***	-8.474***	-7.339***	2009:02	2012:05
s	-2.699	-10.47***	-2.752	-7.921***	-5.167**	2005:10	2011:01
vol	-1.707	-17.78***	-2.212	-5.97***	-5.735***	2006:04	2010:02

Notes: (a) The AIC has selected optimum lag length. (b) All of the unit root tests include an intercept and trend term. (c) ***, **, and * denote the statistical significance level of the estimated coefficients at 1%, 5%, and 10% significance level, respectively.

Table 1 also presents Narayan and Popp (2010) unit root test considering two structural breaks. We find that all the variables have two structural breaks at different months within the sample period except income. Therefore, we include the break dates of the dependent variable, and two dummy variables are generated for these two breaks in Equation (3) to accommodate the effect of structural change. After incorporating the structural breaks, the money demand function can be defined as

$$\begin{aligned}\Delta m_t = \alpha &+ \sum_{i=1}^{a} \gamma_i \Delta m_{t-i} + \sum_{i=1}^{b} \eta_i \Delta y_{t-i} + \sum_{i=1}^{c} \lambda_i \, \Delta i_{t-i} + \sum_{i=1}^{d} \varphi_i \, \Delta s_{t-i} \\ &+ \sum_{i=1}^{e} \omega_i^+ \, \Delta vol_{t-i}^+ + \sum_{i=1}^{f} \omega_i^- \, \Delta vol_{t-i}^- + \sum_{i=1}^{g} \xi_i \, \Delta SB_{1,t-i} \\ &+ \sum_{i=1}^{h} \pi_i \, \Delta SB_{2,t-i} + \rho_0 m_{t-1} + \rho_1 y_{t-1} + \rho_2 i_{t-1} + \rho_3 s_{t-1} \\ &+ \rho_4 vol_{t-1}^+ + \rho_5 vol_{t-1}^- + \rho_6 SB_{1,t-1} + \rho_7 SB_{2,t-1} + \varepsilon_t \end{aligned} \tag{6}$$

where, $SB_1 = 1$ if t > 2007:M2 and 0 otherwise and, likewise, $SB_2 = 1$ if t > 2011:M12 and 0 otherwise.

Now, Table 2 reports the results obtained from the nonlinear ARDL test and the diagnostic measures. Part (a), Part (b), and Part (c) present the short-run coefficients, long-run normalized coefficients, and a battery of diagnostic measures of the estimated models, respectively. In the short run, income and exchange rate positively affect the demand for money in Bangladesh. These findings are consistent with the post prior empirical works conducted in the context of Bangladesh. For example, Ahmed (1999) also found a significant positive effect of income and real exchange rate on M_2 in the short run. However, we find the interest rate does not affect the money holding decisions within the short run. Finally, the main attribute of this paper is that, unlike previous studies on Bangladesh, it investigates the money demand function of Bangladesh incorporating economic uncertainty effect. The coefficients of vol^+ and vol^-

show that people hold less money and probably allocate their money in less risky assets when volatility increases and, on the contrary, people hold more money when volatility decreases. Such relation is comparable to Bahmani-Oskooee and Maki-Nayeri (2019). The findings imply that people's response to economic uncertainty is counterintuitive to the precautionary effect. All these findings remain consistent after considering structural breaks. Moreover, structural changes adversely affect the demand for money.

Part (b) All the long-run estimates are consistent with the theory and empirical studies, implying a stable money demand function of Bangladesh. Like short-run estimates, the positive effects of income and exchange rate remain unaltered in the long run. The income elasticity is less than one, while the exchange rate elasticity is around one. The interest rate effect becomes significant in the long run, and it has an unfavorable impact on the demand for money. Specifically, keeping other things equal, people hold about 6% less money if the interest rate increases by 1%. The long-run coefficients' signs are consistent with the prior studies, although their magnitudes differ to some extent. For instance, the long-run income elasticities of broad money in Islam (2000), and Ahmed and Islam (2005) are 1.60 and 1.89, respectively. In the case of the USA, Ball (2001) also found that income elasticity was significantly smaller in the postwar time (1947-94) than the elasticity in the prewar time (1903-45). Fischer (2007) argued that the income elasticity falls over time because of widening services of financial institutions (for instance, availability of automatic teller machine or ATM). In contrast to the income elasticity, the exchange rate elasticity is larger than the previous studies (see Narayan, Narayan, and Mishra, 2009; Hossain, 2010). Since trade openness, remittance earnings of Bangladesh increase, the sensitivity of demand for money to the foreign exchange rate also intensifies over time.

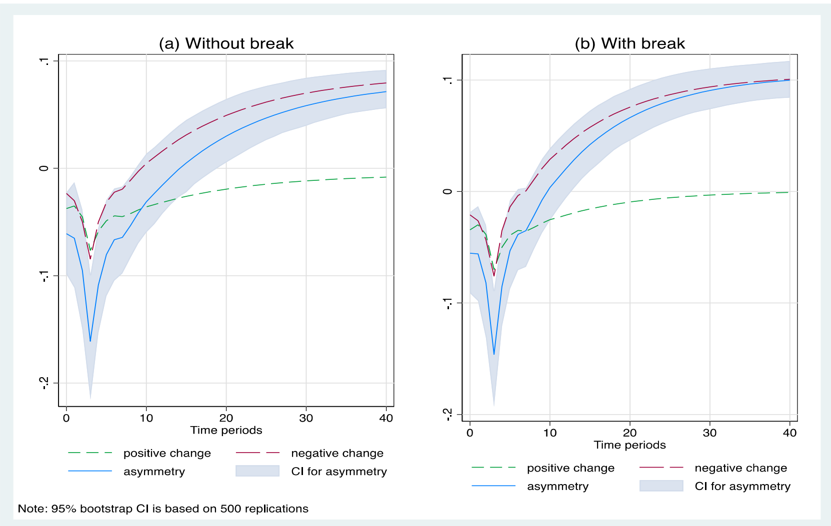

Figure 1. Cumulative asymmetric effects of volatility on demand for money

However, unlike the short-run elasticity of economic uncertainty, demand for money falls as economic uncertainty declines. In addition, people's decision regarding holding money is not sensitive to economic uncertainty in the long run when the uncertainty increases. Probably, people find enough time to cope with the increasing uncertain prospect in the long run. Moreover, when uncertainty decreases in the long run, people change their portfolios and allocate their money in assets. Therefore, the demand for holding money declines in the long run at decreased uncertainty. Finally, only the first break has a significant adverse effect on the demand for money.

The dynamic asymmetric adjustments of demand for money after positive and negative shocks of economic uncertainty are also illustrated in Figure 1. According to the dynamic multiplier, the negative shock has a dominant influence on demand for money.

The calculated F and t statistics exceed the critical values of Pesaran, Shin, and Smith (2001) and Kripfganz and Schneider (2020) at 1% and 5% significance levels, respectively. The ARDL bounds tests confirm that the real cash balance is cointegrated with the considered variables.

Table 2. Results of nonlinear ARDL model

Part (a): Short-run Coefficient Estimates

	Without Breaks				With Breaks			
Lag order	0	1	2	3	0	1	2	3
Variables								
Δm		-0.2620***	-0.0474	-0.1034*		-0.2882***	-0.0578	
		(0.0669)	(0.0654)	(0.0592)		(0.0649)	(0.0579)	
Δy	0.0823***	0.0338**	-0.0154		0.0856***	0.0507***		
	(0.0126)	(0.0151)	(0.0139)		(0.0121)	(0.0134)		
Δi	-0.0005	0.0027			-0.0005	0.0039	0.0006	
	(0.0028)	(0.0029)			(0.0027)	(0.0030)	(0.0028)	
Δs	0.3001***	0.1876**	-0.2383***	0.0055	0.3004***	0.2059***	-0.2574***	
	(0.0678)	(0.0768)	(0.0781)	(0.0773)	(0.0689)	(0.0776)	(0.0779)	
Δvol^{+}	-0.0333***	-0.0111	-0.0089	-0.0397***	-0.0252**	-0.0119	-0.0099	-0.0341***
	(0.0103)	(0.0101)	(0.0100)	(0.0104)	(0.0104)	(0.0100)	(0.0098)	(0.0100)
Δvol^{-}	0.0230**	0.0328***	0.0293**	0.0539***	0.0148	0.0333***	0.0355***	0.0487***
	(0.0113)	(0.0117)	(0.0114)	(0.0110)	(0.0112)	(0.0114)	(0.0108)	(0.0116)
ΔSB_1					-0.0168***			
					(0.0055)			
ΔSB_2					-0.0251*	0.0021	0.0176	0.0121
					(0.0132)	(0.0126)	(0.0123)	(0.0120)

Part (b): Long-run Coefficient Estimates

	$Constant$	y	i	s	vol^{+}	vol^{-}	SB_1	SB_2
Without Breaks	1.5923	0.3562***	-0.0644***	1.0751***	0.0006	-0.0986***		
	(0.3550)	(0.1060)	(0.0255)	(0.2132)	(0.0304)	(0.0292)		
With Breaks	2.0675***	0.1811*	-0.0624***	0.8199***	-0.0073	-0.1329***	-0.1564***	0.0272
	(0.4106)	(0.0977)	(0.0217)	(0.1893)	(0.0322)	(0.0334)	(0.0468)	(0.0437)

Table 2. Results of nonlinear ARDL model (cont.)

Part (c): Diagnostic Tests

	ARDL Bounds Tests		ECT_{t-1}	W_{LR}	W_{SR}	$\bar{R}^2$	χ^2_{SC}	χ^2_{H}	χ^2_{SK}	χ^2_{KT}	χ^2_{FF}
	F	t									
Without Breaks	8.296***	-4.712**	-0.0906***	66.18***	29.39***	0.4635	0.109	230	34.07	0.99	4.87***
With Breaks	6.539***	-5.02**	-0.1072***	93.87***	23.65***	0.4908	4.129	230	30.92	0.03	1.5

Notes: (a) The AIC has selected the optimum lag length. (b) ***, **, and * denote the statistical significance level of the estimated coefficients at 1%, 5%, and 10% significance level, respectively. (c) The F and t in the ARDL bounds tests are compared with the upper bound critical values obtained from Pesaran et al. (2001) and Kripfganz and Schneider (2020). (d) The values of standard errors are in the parentheses. (e) ECT_{t-1} presents the speed-of-adjustment coefficient. (f) χ^2_{SC}, χ^2_{H}, χ^2_{SK}, χ^2_{KT}, χ^2_{FF} denote serial correlation, White's test of homoscedasticity, skewness, and kurtosis, Ramsey RESET test for omitted variables, respectively. (g) W_{LR} and W_{SR} present the values of the Wald statistic of long-run symmetry and summative short-run symmetry, respectively. (h) $\bar{R}^2$ reports adjusted R^2.

Table 3. Causality tests results

Toda & Yamamoto Causality Test			**Cumulative Fourier-frequency Toda & Yamamoto Causality Test**		
Null hypothesis	**Wald statistic**	**Decision**	**Null hypothesis**	**Wald statistic**	**Decision**
$\boldsymbol{y \nRightarrow m}$	33.59***	$\boldsymbol{y \Leftrightarrow m}$	$\boldsymbol{y \nRightarrow m}$	32.63***	$\boldsymbol{y \Rightarrow m}$
$\boldsymbol{m \nRightarrow y}$	19.82*		$\boldsymbol{m \nRightarrow y}$	18.54	
$\boldsymbol{i \nRightarrow m}$	6.31	$\boldsymbol{i \nLeftrightarrow m}$	$\boldsymbol{i \nRightarrow m}$	10.51	$\boldsymbol{i \nLeftrightarrow m}$
$\boldsymbol{m \nRightarrow i}$	7.61		$\boldsymbol{m \nRightarrow i}$	10.42	
$\boldsymbol{s \nRightarrow m}$	14.38	$\boldsymbol{s \Leftarrow m}$	$\boldsymbol{s \nRightarrow m}$	25.66**	$\boldsymbol{s \Leftrightarrow m}$
$\boldsymbol{m \nRightarrow s}$	40.86***		$\boldsymbol{m \nRightarrow s}$	31.80***	
$\boldsymbol{vol \nRightarrow m}$	18.42	$\boldsymbol{vol \nLeftrightarrow m}$	$\boldsymbol{vol \nRightarrow m}$	22.09**	$\boldsymbol{vol \Rightarrow m}$
$\boldsymbol{m \nRightarrow vol}$	9.65		$\boldsymbol{m \nRightarrow vol}$	9.59	

Note: (i) ***, **, and * denote the statistical significance level of the estimated coefficients at 1%, 5%, and 10% significance level, respectively. The values are obtained from the bootstrap distribution with 1,000 replications. Here these findings are consistent with the asymptotic chi-square distribution of the Wald statistic (ii) the AIC has selected optimum lag length. (iii) The direction of causality among the rest of the variables are available upon request.

The error correction terms (ECT_{t-1}) are significant at a 1% significance level and have expected negative signs. The speed of adjustment is about 10% each month. Consequently, the adjustment process takes less than one year to restore its long-run equilibrium. The Wald test statistics support short-run and long-run asymmetric effects of economic uncertainty since their estimates are significant at a 1% significance level. Except for the Ramsey RESET test, the rest of the diagnostic measures support that Equation (3) is correctly specified. χ^2_{FF} shows that either the model commits incorrect functional form or excludes relevant variable(s) from the model. However, such misspecification disappears as the structural breaks are included in Equation (6). Figure 2 illustrates the recursive CUSUM plot to present the stability of parameters reported in Table 2. These two plots ensure the stability of the parameters since the curves do not cross the upper and lower bounds at a 95% confidence level.

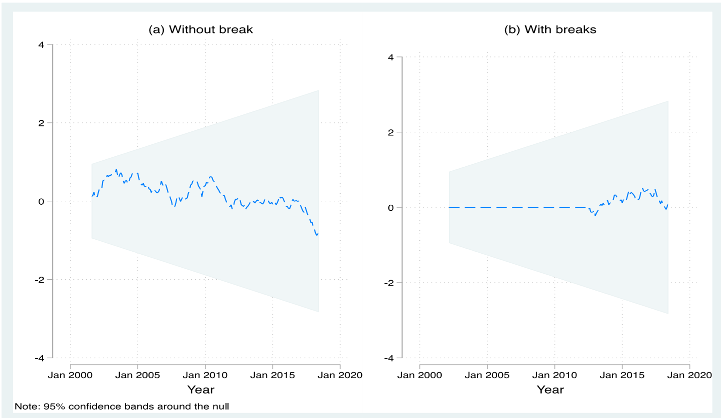

Figure 2. The recursive CUSUM plot

Table 3 presents causality test results. According to Toda and Yamamoto (1995) causality test, if we compare the direction of causality in terms of money with the rest of the variables, we find only money and income have a bidirectional causal relationship. Using error correction framework, Hossain (2011) also found such bidirectional causality between money and output. This bidirectional causality validates Keynesian and monetarist' hypotheses. Money also causes the exchange rate. However, interest rate, exchange rate, and uncertainty do not cause money.

In contrast to the earlier studies on money demand function, another novelty of this study is that it incorporates recently developed cumulative Fourier-frequency Toda and Yamamoto causality test. The Fourier causality test considers nonlinearities with smooth structural breaks. The cumulative Fourier-frequency Toda-Yamamoto causality test demonstrates that income, and uncertainty cause money. Moreover, there is bidirectional causality between money and the exchange rate. Hence, the recently developed causality test validates only the Keynesian hypothesis that income causes money and rejects the monetarists' hypothesis for Bangladesh since money does not cause income.

4. Conclusions

The monetary policy of Bangladesh aims to attain a higher economic growth target and price level stability. However, a stable money demand function is a prerequisite to executing the monetary policy successfully. Though many studies estimated the money demand function of Bangladesh, none of these studies considered uncertainty in their analysis. However, uncertainty emerged as an essential determinant of money demand function since the 1980s.

Therefore, we consider output uncertainty in estimating the demand for holding money in this study, covering monthly data from 1999:M1 to 2018:M6. We employ recently developed time series econometrics tools.

We find that output and exchange rate have positive and statistically significant effects on the demand for money in the short and long run. Comparing to the earlier studies, we find that income elasticity decreases while exchange rate elasticity increases. The favorable exchange rate effect implies that the wealth effect dominates the substitution effect in liquidity preference. On the contrary, the demand function is not sensitive to interest rate within the short run. However, it negatively affects the demand function in the long run. Consequently, the interest rate is merely a long-run phenomenon in Bangladesh’s money demand function. It implies that people do not promptly respond to the interest rate.

We find asymmetric effects of income uncertainty on Bangladesh’s money demand function in the short run and long run. People hold less money and probably invest money in low volatile assets in the short run when uncertainty increases. However, the significant effect of increased uncertainty is a short-run phenomenon; it does not sustain in the long run. Unlike increased uncertainty, liquidity preference induces in the short run and declines in the long run when uncertainty decreases. The Wald test statistics also support the asymmetric effect, and the dynamic multiplier illustrates that the negative uncertainty is dominant in determining the liquidity preference.

Considering the debate between the Keynesian and monetarist schools of thought about the direction of causality between money and income, we find bidirectional causality when we disregard nonlinearities and smooth structural breaks. On the contrary, a unidirectional causality from income to money is found when we allow smooth breaks. Consequently, the Keynesian hypothesis is robust for Bangladesh.

This study considers only output uncertainty in estimating the money demand function of Bangladesh. In addition, one can further investigate the money demand function considering monetary uncertainty (for instance, Friedman, 1984; Hall and Noble, 1987), interest rate uncertainty (for example, Baba, Hendry and Starr, 1992).

Overall, the demand for broad money in Bangladesh is stable, and uncertainty should be included in estimating the money demand function since it has both short-run and long-run impacts. Policymakers can undertake monetary policy to achieve the macroeconomic target. However, as we find little evidence for monetarist’s hypothesis regarding the direction of causality from money to income, fiscal policy may be considered along with a monetary policy to tune the economy.

References

Ahmed, N., (1999), "The Demand for Money in Bangladesh During 1975-1997: A Cointegration Analysis," *Indian Economic Review*, 34(2), 171-185.

Ahmed, S., (1977), "Demand for Money in Bangladesh: Some Preliminary Evidences," *The Bangladesh Development Studies*, 5(2), 227-237.

Ahmed, S. and M.E. Islam, (2005), "Demand for Money in Bangladesh: A Cointegration Analysis," *Bangladesh Development Studies*, 31(1-2), 103-120.

Baba, Y., D. F. Hendry, and R. M. Starr, (1992), "The Demand for M1 in the U.S.A., 1960-1988," *Review of Economic Studies*, 59, 25-61.

Bahmani-Oskooee, M. and A.C. Arize, (2020), "On the Asymmetric Effects of Exchange Rate Volatility on Trade Flows: Evidence from Africa," *Emerging Markets Finance and Trade*, 56(4), 913-939.

Bahmani-Oskooee, M., and M. Maki-Nayeri, (2019), "Asymmetric Effects of Policy Uncertainty on the Demand for Money in the United States," *Journal of Risk and Financial Management*, *12*(1).

Bahmani-Oskooee, M., D. Xi and Y. Wang, (2012), "Economic and Monetary Uncertainty and the Demand for Money in China," *Chinese Economy*, 45(6), 26–37.

Bahmani-Oskooee, M., F. Halicioglu and S. Bahmani, (2017), "Do Exchange Rate Changes Have Symmetric or Asymmetric Effects on the Demand for Money in Turkey?" *Applied Economics*, 49(42), 4261-4270.

Bahmani-Oskooee, M., K. Satawatananon and D. Xi, (2015), "Economic Uncertainty, Monetary Uncertainty, and the Demand for Money in Thailand," *Global Business and Economics Review*, *17*(4), 467-476.

Bahmani-Oskooee, M. and D. Xi, (2011), "Economic Uncertainty, Monetary Uncertainty and the Demand for Money in Australia," *Australian Economic Papers*, *50*(4), 115-128.

Ball, L., (2001), "Another Look at Long-run Money Demand," *Journal of Monetary Economics*," 47, 31–44.

Brüggemann, I., and D. Nautz, (1997), "Money Growth Volatility and the Demand for Money in Germany: Friedman's volatility hypothesis revisited," *Review of World Economics*, *133*(3), 523-537.

Choi, W. G. and S. Oh, (2003), "A Money Demand Function with Output Uncertainty, Monetary Uncertainty, and Financial Innovations," *Journal of Money, Credit, and Banking*, *35*(5), 685-709.

Fischer, A. M., (2007), "Measuring Income Elasticity for Swiss Money Demand: What Do the Cantons Say about Financial Innovation?" *European Economic Review*, 51(7), 1641-1660.

Friedman, M., (1956), The Quantity Theory of Money - A Restatement. In *Studies in the Quantity Theory of Money*, edited by Milton Friedman, 3-21. Chicago: University of Chicago Press.

Friedman, M., (1984), "Lessons from the 1979-1982 Monetary Policy Experiment," *American Economic Review*, 74(2), 382-387.

Gormus, A., S. Nazlioglu and U. Soytas, (2019), "High-yield Bond and Energy Markets," *Energy Economics*, 69, 101-110.

Hall, T. and N. Noble, (1987), "Velocity and the Variability of Money Growth: Evidence from Granger-Causality Tests: Note," *Journal of Money, Credit and Banking*, 19(1), 112-116.

Hossain, A. A., (2010), "Monetary Targeting for Price Stability in Bangladesh: How Stable Is Its Money Demand Function and the Linkage between Money Supply Growth and Inflation?" *Journal of Asian Economics*, 21(6), 564-578

Hossain, M.A., (2011), "Money-Income Causality in Bangladesh: An Error Correction Approach," *Bangladesh Development Studies*, 34(1), 39-58.

Islam, M. A., (2000), "Money demand function for Bangladesh. Bangladesh Development Studies," 26(4), 89–111.

Keynes, J. M., (1936), *The General Theory of Employment, Interest and Money*. *London, Macmillan.*

Kripfganz, S. and D. Schneider, (2020), "Response Surface Regressions for Critical Value Bounds and Approximate p-values in Equilibrium Correction Models," *Oxford Bulletin of Economics and Statistics*, 82(6), 1456-1481.

Mundell, A. R., (1963), "Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates," *Canadian Journal of Economics and Political Science*, 29(4), 475-85.

Murad, S.M.W., R. Salim and M.G. Kibria, (2021), "Asymmetric Effects of Economic Policy Uncertainty on the Demand for Money in India," *Journal of Quantitative Economics*, 19.

Murti, G.V.S.N. and S. Murti, (1978), "The Functional Form of Demand for Money in Bangladesh," *Bangladesh Development Studies*, 6(4), 443-460.

Narayan, P.K. and S. Popp, (2010), "A New Unit Root Test with Two Structural Breaks in Level and Slope at Unknown Time," *Journal of Applied Statistics*, 37(9), 1425-1438.

Narayan, P.K., S. Narayan and V. Mishra, (2009), "Estimating money demand functions for South Asian countries," *Empirical Economics*, 36, 685–696.

Ö zdemir, K. and M. Saygili, (2013), "Economic Uncertainty and Money Demand Stability in Turkey," *Journal of Economic Studies*, 40(3), 314-333.

Pesaran, M. H., Y. Shin and R. J. Smith, (2001), "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, *16*(3), 289-326.

Phillips, P. C. B., and P. Perron, (1988), "Testing for a Unit Root in Time Series Regression," *Biometrika*, 75, 335–346.

Rodrigues, P. M. and A.M.R. Taylor, (2012), "The Flexible Fourier Form and Local Generalised Least Squares De-trended Unit Root Tests," *Oxford Bulletin of Economics and Statistics*, 74(5), 736-759.

Siddiki, J. U, (2000), "Demand for Money in Bangladesh: A Cointegration Analysis," *Applied Economics*, 32(15), 1977-1987.

Taslim, M.A., (1984), "On Rate of Interest and Demand for Money in LDCs: The Case of Bangladesh," *The Bangladesh Development Studies*, 12(3), 19-36.

Toda, H.Y. and T. Yamamoto, (1995), "Statistical Inference in Vector Autoregression with Possibly Integrated Processes," *Journal of Econometrics*, 66(1-2), 225–250.