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Stability of Money Demand Function in the SAARC Region: A Panel Co-Integration Approach

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Abstract This study explores the causality relationships between money demand, real income, price, and interest rate by focusing on South Asia for the period between 1986 and 2017 using panel data econometrics. Our estimations based on panel auto-regressive distributed lag (ARDL) reveal a significant and positive long-run relationship between real income and money demand, while a negative relationship exists with interest rate and price. The panel vector error correction model causality results highlight a feedback relationship between money demand and real income, but a short-run unidirectional causality between price and interest rate and real income. We also discover long-run bidirectional causality among these variables. Our results indicate that the money demand function was stable in South Asian economies during the time period considered by this study. Therefore, the central bank of these countries can use money supply as an appropriate instrument to manage monetary policy to achieve overall price and macroeconomic stability.

Keywords: Money Demand, Panel ARDL, Granger Causality, Interest Rate.

JEL Classifications: E41, E51, E52, E42

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I. Introduction

Monetary authorities implement monetary policies to maintain economic growth and stability. Monetary policy framework relies on estimating the money demand function because it provides a foundation for macroeconomic modeling in many countries. The stability of economic policy instruments such as money supply, interest rate, and inflation are the fundamental factors for determining economic growth rates. Understanding the relationships between the money demand

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function and its determinants is important for exploring theories of macroeconomic behavior and implementing appropriate macroeconomic policies (Goldfeld 1994). Consequently, the demand for money and its functional specification has remained a contemporary issue subject to extensive empirical scrutiny in panel studies (Dobnik 2011, Dreger *et al*. 2000, Garcia-Hiernaux and Cerno 2006, Lee and Chang 2013).

The estimated relationship between the determinants of money demand provides guidance to central banks in the implementation of suitable monetary policies (Foresti and Napolitano 2013). Central banks of developing economies use the interest rate as the most appropriate instrument of monetary policy even though there is no robust evidence to confirm that their specific money demand functions are unstable (Rao and Kumar 2009). In a developing economy, if the interest rate is chosen as a monetary policy instrument rather than the money supply, monetary policy is ineffective when the money demand function is stable (Poole 1970, Rao and Kumar 2008). An earlier study by Bahmani-Oskooee and Rehman (2005) found that the demand functions of money are stable in many developing Asian countries even though such evidence is largely missing in the South Asian context. Therefore, it is important to understand from an economic policymaking perspective that the demand for money functions in South Asian developing countries has become unstable.

This paper aims to explore the meaningful causal relationships among the determinants of money demand functions in South Asia. The researchers apply panel data econometrics using a panel co-integration approach for this purpose. The underlying assumption of our study is that money demand estimations are an integral aspect of the monetary policy framework, while the stability of money demand is a necessary condition for using monetary aggregates in conducting macroeconomic policy (Goldfeld and Sichel 1990). This study seeks to provide empirical evidence regarding the impact of real income, overall price levels, and real interest rates on the demand for money in South Asia. We consider the South Asian Association of Regional Cooperation (SAARC) region for our analysis because these economies are responsible for promoting the development of economic and regional integration in South Asia. Monetary policy in the SAARC region also aims to achieve the twin objectives of fostering economic growth and encouraging overall price stability.

We apply a pool mean group (PMG) estimator based on Pesaran *et al*. (1999) to an unbalanced data for our analysis. We further compare the results from the PMG with two alternative panel estimation methods, namely mean group (MG) and dynamic fixed effect (DFE) estimators, to ensure the efficiency and consistency of the estimates. The contribution of this study to the existing literature on the relationship between the determinants of money demand is documented through two possible channels. First, we examine the impact of real income on money demand in South Asian economies. Second, we demonstrate that both money demand and interest rate are important for monetary policy formation even though the existing literature predominantly incorporates short-term interest rates in the Equation for money demand. An over-reliance on short-term interest rates is problematic because this does not allow the opportunity cost of holding money to be fully captured (Valadkhani 2008). Our paper also differs from a previous study by Kumar *et al.* (2009) in two ways. First, we consider long-term instead of short-term interest rate for our analysis. Second, Kumar *et al.* (2009) only investigated long-run relationships among the determinants of money demand but we analyze short-run relationships as well.

The remainder of the article is structured as follows. Section 2 summarizes the relevant literature. The data, theoretical models, and econometric methodologies applied to estimate the money demand function are discussed in Section 3. Section 4 presents and discusses the results. Section 5 highlights future areas for research and concludes the study.

II. Literature Review

Monetarists believe that the regulation of an economy by means of money supply and interest rates is a way to drive economic growth. The establishment of a modeling framework to estimate money demand functions is, therefore, quite important for the effective management of macroeconomic policies (Lucas 1988, Stock and Watson 1993). Monetary policies rely on the determination of a well-specified money demand function and accurately modeled relationships between its determinants (Laidler 1999). Earlier studies have shown that the long-run efficiency of interest rate policy might be impacted by any disequilibrium or disturbance in the demand for money (Ball 2001, Gerlach and Svensson 2003). Yoshino *et al.* (2017), for instance, showed that monetary policy instruments, such as negative interest rates in Japan, have been ineffective in stimulating a recovery in the Japanese economy.

As a result, empirical estimations of money demand functions using panel data are widely captured in the literature (Bahmani 2015, Carrera 2008, Dreger and Wolters 2010, Dreger and Wolters 2014, Dobnik 2011, Elbadawi and Schmidt-Hebbel 2007, Fidrmuc 2009, Hamori 2008, Hamori and Hamori 2008, Harb 2004, Khalid *et al.* 2010, Kjosevski *et al.* 2016, Kumar *et al.* 2013, Mark and Sul 2003, Nautz and Rondorf 2011, Tang 2007, Valadkhani 2008, Valadkhani and Alauddin 2003). Dilan and Örsal (2017) demonstrated that the long-run demand for money in 13 Organisation for Economic Co-operation and Development (OECD) economies was driven by the interdependence between cross-sections in the sample. Kumar *et al.* (2009) showed that the determinants of money demand formed a long-term equilibrium relationship within each of five South Asian economies, as well as for a group of five South Asian economies as a whole. Nepal's money demand function was unstable but that of the other four countries was stable, which contradicted the findings of an earlier study by Buddha (2011) in which a stable money demand function for Nepal was established.

Nautz and Rondorf (2011) applied a PMG estimate to explore cross-country perspectives on money demand and its determinants in the European area. Variable omissions in money demand model specification led to instability in the standard money demand models estimated for these countries. Rao and Kumar (2009) employed the co-integration technique of money demand for 14 Asian economies and concluded that money supply, not the interest rate, should be the focal instrument of monetary policy advocated by their central banks. Harb (2004) investigated the demand function for money in six Gulf region economies by employing the panel co-integration procedure based on Pedroni (1999). The study by Harb (2004) confirmed that the determinants of money demand form a stable, long-term equilibrium relationship.

Foresti and Napolitano (2013) employed the panel dynamic ordinary least squares (DOLS) estimate methodology in order to capture the long-run estimates of money demand for nine OECD economies. The results showed that wealth and real income had an intensified role in determining money demand while the incorporation of wealth into the model specification increased the stability of the demand function. Simmons (1992) estimated the money demand for five African economies using an error correction model and concluded that domestic interest rates and overall price levels play an important role as determinants of money demand. Taghizadeh-Hesary *et al*. (2018) examined the impact of price transfers in order to analyze their inflationary effects and concluded that the effect of prices on the economy is in their effect on household expenditures, which, in turn, influence aggregate demand. Another study by Taghizadeh-Hesary and Yoshino (2014) showed that expansionary monetary policies induced through interest rate manipulation were the cause of an overall long-term price increase throughout the economy.

Kjosevski *et al*. (2016) analyzed the stability of the money demand functions of five western Balkan economies using the DOLS technique and confirmed the existence of a long-run equilibrium relationship as well as the stability of the money demand function. Nominal interest rates, exchange rates, inflation, and real money showed a long-run equilibrium relationship between the economies of the five Balkan countries. Dobnik (2011) found long-run equilibrium in the money demand functions of 11 OECD economies based on the panel error correction model. Income had a positive impact on the demand for money while interest rate and stock prices generated negative impacts. Apergis (2015) estimated a money demand specification model based on an ordinary least squares estimation using a panel framework to account for structural breaks in East Asian economies. The empirical findings provided valuable guidance to East Asian monetary authorities and central banks as their money demand responded positively to real income and was inversely related to interest rate increases, the effective exchange rate, inflation, and the United States (US) real interest rate.

III. Methodology and Data

The sub-sections below describe the data, the model specifications, and the econometric methodologies applied in our study.

A. Data

The variables used in our analysis are as follows: M2 is the nominal broad money supply initially obtained in local currency but transformed into real broad money supply M2 (in billions of US dollars) and deflated by the gross domestic product (GDP) deflator where 2010 is the base year (2010=100); real GDP is a measure of income (in constant 2010 US dollars) in billions; the price variable is the consumer price index where 2010 is the base year (2010=100); and the real interest rate is the inflation-adjusted lending interest rate. All data are retrieved from the World Development Indicators (WDI) published by the World Bank (WDI 2019). The data sample consists of seven South Asian economies, namely Nepal, India, Bhutan, the Maldives, Bangladesh, Sri Lanka, and Pakistan. The dataset is an unbalanced panel since there are data gaps in our sample. Therefore, the period of analysis runs from 1986 to 2017 for Nepal, Bangladesh, the Maldives, Bhutan, and India. Likewise, the period of analysis respectively runs from 2004 to 2017 and from 2001 to 2016 for Pakistan and Sri Lanka (please see Appendix for more information).

B. Model specifications

We began our analysis by creating a specification for the money demand function as in earlier studies (Beyer 2009, Driscoll 2004, Ericsson 1998, Harb 2004). This is primarily because understanding how the demand for money responds to its determinants, such as the overall price level and interest rate, is a foundational goal in the pursuit of monetary policy objectives. Equation 1 below is a standard specification of the money demand function to test for a long-run equilibrium relationship (i.e. co-integration) among its determinants:

$$lnM2_{it} = \beta_0 + \beta_1 ln Y_{it} + \beta_2 lnP_{it} + \beta_3 IR_{it} + \epsilon_{it} \tag{1}$$

where *M2* is the real aggregate monetary term, *Y* is income in real terms, *P* is the consumer price index, *IR* is the real interest rate, and country and time are represented by the subscripts *i* and *t*, respectively, and ε_{it} is the normally distributed residual term. All variables, except for real interest rate, are log transformed by taking their natural logarithms.

We expected a positive coefficient for income β_1 with a value exceeding 1, although this value tends to differ across studies. Foresti and Napolitano (2013) have shown that the value of β_1 usually falls between 1 and 2 with two theoretical implications. The quantity theory of money (Friedman 1956) is supported when the value of $\beta_1 = 1$, while $\beta_1 = 0.5$ confirms the theory advocated by Baumol-Tobin (Baumol 1952 Tobin 1956). The value and sign of β_1 has macroeconomic policy implications, for example, a value of less than 1 rules out the optimality conditions under the Friedman rule whereby output must grow faster than money demand in order for macroeconomic price stability to be attained (Ball 2001). Price is used as a proxy for the rate of inflation, in that it captures the returns of holding onto goods and foreign currencies as per Ericsson (1998).

C. Econometric approaches

The sub-sections below describe the econometric methodologies based on panel co-integration, the panel Auto-Regressive Distributed Lag (ARDL) model, and the Granger causality tests on the panel data, respectively.

1. Panel co-integration approach

We then applied the panel co-integration test proposed by Pedroni (1999). This method accommodates for heterogeneity among the individual cross-sections to test for the null hypothesis of no co-integration (i.e. no long-run equilibrium relationship) existing in the dynamic panel. Pedroni (1999) extended the two-step strategy proposed by Engle and Granger (1987) to test for co-integration and error correction in the panel data application by applying the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) principles. Equation 2 is specified below:

$$y_{it} = \alpha_i + \delta_i t + \theta_t + \beta_{1i} x_{1it} + \cdots + \beta_{Mi} x_{Mit} + \varepsilon_{it} \tag{2}$$

where the number of cross-sectional units and time observation are represented by $(i = 1, \cdots, N)$ and $(t = 1, \cdots, T)$, respectively, and M is the number of regressors. This can be seen as a fixed-effects model where, α_i, $\delta_i t$, and θ_t represent individual specific effect, individual specific linear trend, and common time effect, respectively. The heterogeneity of the coefficients is captured by β_{Mi}.

To test the stationarity property of the error process, Pedroni (1999) suggested conducting seven tests that are distributed asymptotically normally to a standard distribution. The seven test statistics can be classified as “within dimension tests” and “between dimension tests.” The “within dimension tests” statistic assumes the homogeneity of the restricted auto-regressive parameter on the estimated residuals for all countries included in our sample. The four test statistics under the “within dimension tests” statistic include the panel v-statistic, panel p-statistic (rho statistic), panel PP-statistic, and panel ADF-statistic. A large positive value for panel v-statistics rejects the null hypothesis of no co-integration. The “between dimension tests” include the group p-statistic, group PP-statistic, and group ADF-statistic. A large negative value implies the rejection of the null hypothesis for all other test statistics except for the panel v-statistics.

2. Panel ARDL approach

We applied the dynamic panel models based on the PMG estimate model proposed by Pesaran *et al.* (1999). It is appropriate to apply the PMG estimator when the length of time series *“T”* exceeds the size of cross-sections *“N”* (*i.e., T > N*). One of the fundamental assumptions of the PMG estimator is that it allows for heterogeneity in the short-term coefficients but does not allow homogeneity in the long-run slope coefficients (Pesaran *et al.* 1999). The long-term coefficients are constrained to be equal to the error correction model, but the long-term coefficients can vary from the error variances. The PMG estimate or panel ARDL have been applied in the earlier works of Dunne and Kasekende (2018), Kjosevski and Petkovski (2017), Mbazia and Djelassi (2019), and Nautz and Rondorf (2011) to estimate the demand for money and identify the determinants of money demand. The panel ARDL of the order *(p, q)* model is formulated below:

$$y_{it}=\sum_{j=1}^{p}\lambda_{ij}y_{i,t-j}+\sum_{j=1}^{q}\delta_{ij}^{'}x_{i,t-j}+\mu_i+\varepsilon_{i,t} \tag{3}$$

where $x_{i,t-j}$ and $\delta_{ij}^{'}$ denote the $k\times 1$ vector of independent variables and the coefficients of independent variables, respectively, and y_{it} denotes the dependent variable, λ_{ij} is a vector of scalars, μ_i is the country specific time invariant fixed effect, and $\varepsilon_{i,t}$ are the residuals.

Equation 4 is the error correction model representation obtained by transforming Equation 3:

$$\triangle y_{i,t}=\varphi_i\left(y_{i,t-1}-\theta_{\alpha,i}-\theta_i x_{i,t}^{'}\right)+\sum_{j=1}^{p-1}\lambda_{i,j}^{*}\triangle y_{i,t-j}+\sum_{j=1}^{q-1}\delta_{i,j}^{*}\triangle x_{i,t-j}^{'}+\eta_i+\varepsilon_{i,t} \tag{4}$$

where, $x_{i,t}=(Income_{i,t}, Price_{i,t}, Interest_{i,t}\ as\ represented\ by\ Equation\ 1)$, $\varphi_i=-(1-\sum_{j=1}^{p}\lambda_{i,j})$, $\theta_i=-\frac{\sum_{j=0}^{q}\delta_{i,j}}{\varphi_i}$, $\lambda_{i,j}^{*}=-\sum_{m=j+1}^{p}\lambda_{i,m}$, $\delta_{i,j}^{*}=-\sum_{m=j+1}^{q}\delta_{i,m}$.

Therefore, the model to be estimated is:

$$\Delta lnM2_{it} = -\mu_i + \varphi_i(lnM2_{it-1} - \lambda_1 lnY_{it-1} - \lambda_2 lnP_{it-1} - \lambda_3 lnIR_{it-1}) + \Sigma_{j-1}^{p-1}\gamma_j^i(\Delta lnM2_i)_{t-j} \quad (5)$$
$$+ \Sigma_{j-0}^{q-1}\delta_{1j}^i \Delta lnY_{it-j} + \Sigma_{j-0}^{q-1}\delta_{2j}^i \Delta lnP_{it-j} + \Sigma_{j-0}^{q-1}\delta_{3j}^i \Delta lnIR_{it-j} + \varepsilon_{it}$$

Equation 4 captures the long-run relationship between money demand and the independent variables based on the term ($\varphi_i(y_{i,t-1} - \theta_{\alpha,i} - \theta_i x_{i,t'})$), where θ_i is the vector of the associated long-term coefficients. A principle property of co-integration is that there are short-run deviations that converge with a speed of φ_i toward the long-run equilibrium in forming the long-term equilibrium relationship, provided that the series is integrated at most to the order of 1 (I (1)) or order of 0 (I (0)). We expect φ_i to be statistically significant and negative. The error correction model (i.e. Equation 4) is estimated based on three estimation techniques: PMG, MG, and DFE. Homogeneity in the long-term relationships allows the PMG estimator to be consistent and efficient (Pesaran *et al.* 1999). The MG estimator calibrates an average of individual parameters from each cross-sectional specific regression while imposing no conditions of homogeneity on any of the parameters, both in the short-term as well as long-term (Pesaran and Smith 1995). The DFE estimator allows for intercept heterogeneity but no homogeneity of all other parameters across individual countries in the sample (Hsiao *et al.* 2002). Finally, we applied the Hausman test to compare the consistency and efficiency properties of these three estimators.

3. Granger causality test approach

We applied the Granger causality test in a vector error correction model (VECM) framework only after confirming a long-run equilibrium relationship based on Pedroni (1999). The VECM Granger causality tests capture the short-run and long-run causality relationships based on the lagged values of the error correction term (ECT (-1)). The Granger causality test model based on VECM is represented below:

$$\begin{bmatrix} \Delta M2_{it} \\ \Delta Y_{it} \\ \Delta P_{it} \\ \Delta IR_{it} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{p-1}^{r} \begin{bmatrix} \beta_{11p} & \beta_{12p} & \beta_{13p} & \beta_{14p} \\ \beta_{21p} & \beta_{22p} & \beta_{23p} & \beta_{24p} \\ \beta_{31p} & \beta_{32p} & \beta_{33p} & \beta_{34p} \\ \beta_{41p} & \beta_{42p} & \beta_{43p} & \beta_{44p} \end{bmatrix} \times \begin{bmatrix} \Delta M2_{it-1} \\ \Delta Y_{it-1} \\ \Delta P_{it-1} \\ \Delta IR_{it-1} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix} ECT_{it-1} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \\ \varepsilon_{4it} \end{bmatrix} \quad (6)$$

where *t* captures the time dimension, *i* indicates the individual countries in the panel $(1,2,\cdots,7$ South Asian countries), ε_{it} is the error term, and *ECT* is the lagged error correction term obtained from the co-integrating Equation represented by Equation 4. The *ECT* term disappears from Equation 6 in the absence of any co-integrating relationships among the variables. The Akaike's information criterion is applied to gauge the optimal lag order as it has powerful properties in small sample like ours (Liew 2004, Lutkepohl 1991). We used χ^2-statistics to conduct the short-run Granger causality test and *t*-statistics of lagged ECT to determine the direction of long-run causality.

IV. The Estimation Results

We undertake these tests to detect the presence or absence of unit roots in the panels to determine the integration order of the time series variables, namely money demand, income, price, and interest rate. The unit root tests are based on Levin, Lin, and Chu (LLC) (Levin *et al.* 2002); Im, Pesaran, and Shin (IPS) (Im *et al.* 2003); the ADF-Fisher chi-square (χ^2); and the PP-Fisher (χ^2) (Maddala and Wu 1999). The results of this panel unit root test are reported in Table 1. Money demand, income, and price variables are stationary at their first differences but non-stationary at other levels, indicating a unit root property. Hence, the application of the panel co-integration and PMG/ARDL tests to confirm the presence or absence of long-term equilibrium relationships between the demand for money, interest rates, overall price levels, and real income, is desirable.

Table 1. Tests of unit roots in panel

Variables	*LLC*	*IPS*	ADF-Fisher χ^2	PP-Fisher χ^2
Level				
lnY	0.380	-0.195	14.193	24.640
lnM2	-1.293	-0.172	11.743	9.869
lnP	-0.149	1.809	11.437	3.575
lnIR	-0.854	-1.519	22.728*	68.005***
1st Difference				
△lnY	-6.229***	-8.128***	88.106***	131.919***
△lnM2	-6.946***	-7.324***	69.023***	78.295***
△lnP	-4.562***	-3.830***	39.660***	38.813***
△lnIR	-11.896***	-14.373***	170.758***	570.003***

(Note) *, **, and *** respectively indicate the significance at 10%, 5%, and 1% levels.

Table 2 presents the results of panel co-integration according to Pedroni (1999, 2004), applied to the four non-stationary variables, namely demand for money, interest rate, overall price level, and real income. The null hypothesis of no co-integration is rejected by a majority of the seven test statistics at the 1% significance level. Therefore, the panel co-integration tests strongly confirm the presence of a long-run equilibrium relationship between the demand for money and its determinants in these seven South Asian economies.

Table 2. Co-integration tests results based on pedroni (1999, 2004).

Panel (within dimension tests)			Group (between dimension tests)		
Statistics	*Value*	*Prob.*	Statistics	*value*	*Prob.*
v-statistic	6.597	0.000***	p -statistic	0.915	0.820
p -statistic	-1.236	0.108	PP-statistic	-5.907	0.000***
PP-statistic	-6.308	0.000***	ADF-statistic	-3.302	0.001***
ADF-statistic	-3.624	0.000***			

(Notes) (i) Pedroni (2004) residual co-integration tests is reported and assumes null of no co-integration
(ii) *, **, and ***, respectively, indicate the significance level at 10%, 5%, and 1%.

We estimated Equation 4 using three different estimators: PMG, MG, and DFE, in columns (1) to (3). Table 3 reports the results based on these three estimators, as well as the Hausman test results. The Hausman tests (Hausman 1978) are necessary to compare an efficient model against a more efficient model that also provides consistent results. We found that this test failed to reject the assumption of the long-run parameter restriction at the 5% level of significance. The Hausman distributed *chi-square* is 7.75 and 0.02 while *Prob>chi2* is 0.065 and 0.99, respectively, both of which exceed the value of 0.05. Thus, the Hausman test confirms that the PMG estimator is the best efficient estimator under the null hypothesis and, hence, is the most appropriate model for our analysis.

The panel ARDL model confirms the presence of a co-integrated relationship. The estimated ECT, or adjustment coefficient (φ_i), is significantly negative, allowing us to conclude that there are short-run deviations in the relationships, converging toward a long-run equilibrium relationship between the demand for money, overall price level, real income, and interest rate. The presence of a co-integrated relationship suggests that using money demand as an instrument of monetary policy has impacts on real income and overall price levels. Table 4 shows that the values of (β_1), or the income elasticities, are greater than 1 (spanning from 1.33 to 1.58), which does not confirm the assumption of the quantity theory of money, which assumes $\beta_1 = 1$. The results from the preferred PMG estimator in column (1) demonstrate that there is a long-run equilibrium relationship since the long-run coefficient of real income is significantly positive and greater than 1. Therefore, we can conclude that the velocity of money declined for these seven South Asian economies during the specified sample time period of this analysis. This result is consistent with the hypothesis supported by the broader definition of money demand (Apergis 2015, Nautz and Rondorf 2011).

We also noticed statistically significant (at the 1% significance level) coefficients of price and interest rate. Likewise, interest rate spread and price have statistically significant negative coefficients of -0.489 and -0.022, respectively. All other things remaining constant, a 1% increase in inflation level tends to decrease the real value of money by 0.489% based on our results. Interest rate increases also contribute to discouraging the holding of real money balances.

Table 3. Hausman tests of the PMG, MG, and DFE estimators

	ARDL (p = 1, q = 1)		
	(1) PMG	(2) MG	(3) DFE
adjustment coefficients (φ_i)			
	-0.3082	-0.5156	-0.2042
	(-2.7140)**	(-2.9590)***	(-4.0316)***
Long-term coefficients (θ_i)			
Y	1.3496	1.5803	1.3322
	(8.5529)***	(3.6773)***	(4.3664)***
P	-0.4890	-1.9434	-0.2979
	(-3.1659)***	(-3.5483)***	(-1.1073)
IR	-0.0215	-0.0080	-0.0071
	(3.1290)***	(0.7340)	(0.4744)
Short-term (δ^*_{ij})			
$\triangle Y$	1.4926	1.1448	0.5819
	(2.3472)**	(-1.0262)	(2.0820)**
$\triangle P$	-0.2401	-0.7302	-0.6465
	(-1.7341)*	(-1.1337)	(-2.4868)**
$\triangle IR$	-0.0013	-0.0020	-0.0026
	(-0.8123)	(-1.0366)	(1.2762)
Constant	-0.0269	-1.0093	-0.1014
	(-0.1458)	(-2.2285)***	(-1.1412)
Number of observation	179	179	179
Number of countries	7	7	7
Hauman test	(PMG vs. MG)[a]	(PMG vs. DFE)[b]	
Chi2	7.7500	0.0200	
Prob.>Chi2	0.06510	0.9992	

(Notes) (i) *, **, and ***, respectively, indicate the significance at 10%, 5%, and 1% levels; the estimated ARDL is of order (1, 1, 1, 1), and the order of variable is money, income, price, and interest.
(ii) [a] H_0: PMG is efficient than MG estimation.
(iii) [b] H_0: PMG is efficient than DFE estimation.

Table 4. Panel granger causality test results

Dependent variable	Causality (short-run)				Causality (long-run)
	$\triangle M2$	$\triangle Y$	$\triangle P$	$\triangle R$	*ECT*
$\triangle M2$		4.812**	10.992**	0.000	-0.015**
		(0.028)	(0.608)	(0.995)	[-2.518]
$\triangle Y$	2.859*		42.119***	3.022*	-0.594**
	(0.091)		(0.000)	(0.082)	[-2.325]
$\triangle P$	1.336	0.685		2.687*	-0.005**
	(0.248)	(0.248)		(0.101)	[-2.741]
$\triangle R$	0.052	0.083	4.561**		-0.598***
	(0.773)	(0.819)	(0.033)		[-6.833]

(Note) *, **, and ***, respectively, indicate the significance at 10%, 5%, and 1% levels.

The results from the ARDL (1, 1, 1, 1) model demonstrate that short-run interest rate dynamics are not impacted by the assumptions while only income influences money demand.

However, it is not possible to maintain an alternative interpretation of the inflation Equation with exogenous money demand if weak exogeneity in the inflation rate is demonstrated (Hendry and Ericsson 1991, Revankar and Yoshino 1990). Therefore, we also conducted tests of weak exogeneity by undertaking a joint exclusion test; the results are reported in Table 4. We cannot reject the null hypothesis of weak exogeneity for the price variable. Therefore, price is treated as an exogenous variable.

Although the co-integration test results confirmed the presence of a long-run equilibrium relationship it cannot determine the direction of causation. Therefore, the Granger causality test is justifiable in order to examine the nature of the causal relationships among the co-integrated variables. We applied the VECM-based Granger causality test to discern the nature of causal relationships, which also allowed us to differentiate between short-term and long-term causal effects. The results of the Granger causality tests are reported in Table 4.

There is an evidence of feedback relationships (i.e. a bidirectional Granger causality) between money demand and real income, respectively, at the 5% and 10% significance levels in the short-term. We also find a short-term feedback relationship between price and interest rate, respectively, at the 5% and 10% significance levels. A one-directional Granger causality runs from price and interest rate to real income as well as from price to money. There is no causal relationship, in a Granger sense, between interest rate and money, unlike the earlier evidence presented by Kumar *et al.,* (2009), which indicated a Granger causation between demand for money and short-term domestic interest rate but no evidence of causality with short-term foreign interest rate.

We found that the ECT coefficients in each model were negatively signed and statistically significant for the estimation of Equation (6) at the 1% and 5% levels of significance. Therefore, there is a feedback relationship among all variables in the long-run: (1) from income, price, and interest rate to money, (2) from money, price, and interest rate to income, (3) from money, income, and interest rate to price, and (4) from money, income, and price to interest rate. An interesting conclusion from the Granger causality results is that the demand for money is linked with price, real income, and interest rate in the long run. Thus, our results are aligned with the expectations of monetary transmission mechanism theories.

V. Conclusions

A prerequisite for the proper management of monetary policy is the existence of a well-specified money demand function. This paper investigates the long-run equilibrium relationships using the panel co-integration methods between the determinants of demand for money such as income, price, and interest rates in South Asian countries. The panel ARDL technique based on Pesaran *et al.* (1999) is applied in order to model a standard money demand function. The tests were carried out on the premise that comparing specific countries' coefficients enable us to capture the heterogeneity among these countries.

The test results from the panel co-integration provided significant evidence of the existence of a stable long-run money demand function for the economies of these seven South Asian countries. Interestingly, the estimation coefficient of income is above one and is statistically positive. Moreover, the price and interest rate are statistically negative and significant. The results provide strong evidence of a theoretically consistent impact of real income, interest rate, and price on money demand. Income is positive and statistically significant while price and interest rate are insignificant in the short-run. Our results from the panel VECM show that there is a feedback relationship between the demand for money and real income, but only a unidirectional causation between price and interest rate to income and price to money. However, there is evidence of bidirectional long-run relationships among all the variables.

Our findings indicate that an increase in real income increases money demand while money demand decreases with a rise in the interest rate, implying that these results are consistent with the theoretical expectations. Monetarists believe that money demand does not affect economic growth, but it does influence inflation. Our findings support a useful policy recommendation for the central banks of the South Asian countries to maintain price stability. Disequilibrium in the money market, such as an excess increase in money supply, can exaggerate inflation and widen the output gap in the future as per our findings. Therefore, these economies should avoid creating any unnecessary disequilibrium in the money market, such as an increase in the money supply, in order to minimize price instability. We conclude that controlling the money supply is a suitable instrument of monetary policy management in South Asian economies.

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Appendix 1. South asian countries and time periods analyzed in the sample data.

Country	Data Period
Bangladesh	1986-2017
Bhutan	1986-2017
India	1986-2017
The Maldives	1986-2017
Nepal	1986-2017
Pakistan	2004-2017
Sri Lanka	2001-2016