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Causal Links between Money, Price, and Output in Bangladesh: A Cointegration and VECM Approach

*Bikash Chandra Ghosh**
*Md. Khairul Islam***
*Md. Elias Hossain, Ph.D****

Abstract

The present study is an effort to investigate the relationship among money, price and output for Bangladesh over the period 1974 to 2012. The estimated results of vector error correction model based on VAR indicate the existence of long-run bidirectional causality between money supply and output, and unidirectional causality from price level to money supply and output. However, in the short-run, the bidirectional causality is found between money supply and price level, and unidirectional causality is found from output to price level. The results suggest that money supply is responsible for increasing price level and thereby inflation is a short-run monetary experience.

Introduction

Bangladesh is a least developed country in the world. It suffers from imperfection in both money and good markets (Ali and Islam, 2010). Despite the existence of imperfection in markets, the economy of the country has grown by around 5.7% per year on average since 1996 (ADB, 2003). However, to keep the growth rate stable, price stability is necessary. Bangladesh Bank, the central bank of Bangladesh, seeks to achieve price stability through the management of money supply and it uses half-yearly monetary policy to guide economic growth by controlling gradual increase in general price level and stabilizing currency. Again, the Bank influences reserve money through indirect market based instruments such as Cash Reserve Ratio (CRR), Statutory Liquidity Ratio (SLR), repo, reverse repo, open market operations, and moral suasion (Alam, 2014, Islam 2008). To conduct monetary policy, the Bank targets the broad money (M2) as an intermediate instrument. The supply of M2 money in the country has increased over the time. It was Tk. 63027.10 crore in fiscal year 1998-99 and increased to Tk. 546028.44 crore in the fiscal year 2012-13 (Bangladesh Bank, 2014). However, an increase in

* Lecturer, Department of Economics, Pabna University of Science & Technology. E-mail: bikasheco_pust@ymail.com

** Lecturer, Department of Economics, Rajshahi University. e-mail: khairul06eco@gmail.com

*** Professor, Department of Economics, Rajshahi University. e-mail: eliaseco@ru.ac.bd

money supply increases the general price level or inflation. The rate of inflation in our country has fluctuated over time. In 1996, the rate of inflation in the country was 2.45% and it was 8.12% in 2010 and 6.8% in 2013 (CPD, 2014). Inflation has negative effect on output growth. It can affect the macroeconomic condition of a country by creating uncertainty in investment in terms of future profitability, reducing export competitiveness through making it more expensive and distorting, borrowing and lending situation etc. Thus, high inflation associated with high price variability can lead to different negative externalities in an economy and a large effect on the economy's efficiency (Sarel, 1995). The growth rate of Bangladesh has also fluctuated over time. It was 4.6% in 1996 and 6.0% in 2013 (GOB, 2014). Since, the money supply influences general price level and an increase in price level influences growth rate. Therefore, it is necessary to explore the causal relationship between them to understand the direction of causality. Thus, the objective of the present study is to examine the existence of causal relationship among money, price and output and to explore the direction of causality among them.

Theoretical Framework

The co-movements of money supply, price level, and national output have significant implication in analyzing macroeconomic performance of a country (Sims, 1972). The proposition that when money supply increases, real output will first increase before the price level increases but real output will die down more rapidly than prices (Chow and Shen, 2005). There is a possibility that money supply may be independent of output and prices, and being an exogenous variable, it may affect output and price level. On the other hand, output and prices may be the major determinants of supply of money, reflecting endogeneity of the money supply (Mishra et al., 2010). Thus, money supply has both endogenous and exogenous properties. Money supply is endogenously determined by changes in real sector in the short-run and in the long-run money supply is determined exogenously (Cagan, 1965). Keynesians argued that changes in income cause changes in money stock through demand for money implying that there exists a unidirectional causality from income to money. In fact, money does not play any significant role in changing income and prices. Similarly, changes in prices are mainly caused by structural factors (Chimobi, 2010). The Monetarists disprove the Keynesians' ideas, and they evident that changes in money supply changes in income and prices. Increase in money supply may lead to increase in output in the short-run, but in the long-run it influences prices only. Hence, the direction of causation runs from money to income and prices without any feedback (Mishra *et al.*, 2010). In view of such theoretical arguments and hypotheses of macroeconomics, it is essential that the issue of short-run and long-run causality among money, price and output should be reinvestigated. It is with this backdrop, the present study revisits the issue in the context of Bangladesh.

Literature Review

There are many empirical studies on the relationship among money, price and output. These studies investigated the long run relationships as well as the impact of monetary policy on income and price level in the context of different countries over different sample periods yielding conflicting evidences on this issue.

Sharma *et al.*, (2010) investigated whether money supply Granger causes output and prices in the context of Indian economy. They examined the issues in order to decompose Granger causality between money supply, prices and output in frequency-domain. They conclude that there is evidence for money-output trade-off in the short-run, but in the long-run, money supply determines prices, not output. The empirical results also found that output and prices do not Granger cause money supply reflecting exogeneity of money supply. Al-Fawwaz *et al.*, (2012) analyzed the short run relationship between money, price, and gross domestic product (GDP) growth in Jordan. They used time series methods for the annual data for the period 1976-2009. The results of the study found that there is no short-term relationship between money supply (M1) and GDP growth. Thus, they summarized that monetary policy has not had any impact on the Jordanian macroeconomic variables, while it found out that there is a causal relationship from money supply to inflation, with a very low degree.

Chowa and Shenb (2012) studied the stability of monetary relations in the course of China's economic development. An error-correction model is used to explain inflation from 1954 to 2002. They found that the relationship among price level, output, and money supply support the Friedman proposition that output reacts to money shocks first but the effect is short-lived and prices react later but the effect lasts longer. Budina *et al.*, (2002) studied the relationship among money, inflation and output in Romania for the period 1992-2000. The authors applied the Johansen procedure for co-integration to test the co-integrating relations between output, inflation and money. They also used vector error correction mechanism, which showed that excess supply of real money contributes significantly to the short-run dynamics of inflation and real money. The evidence suggests that in the period considered, inflation was largely a monetary phenomenon.

Zulkhibri (2007) examined the causality relationship among monetary aggregates, output and prices in the case of Malaysia. The study used a vector auto-regression (VAR) model applying the Granger no-causality procedure developed by Toda and Yamamoto (1995). The results indicate a two-way causality running between monetary aggregates, M2, M3, and output, which are consistent with theoretical conjectures by the Keynesian and Monetarist views whereas there is a one-way causality running from monetary aggregate, M1 to output. In addition, the results suggest that all monetary aggregates have a strong one-way causality running from money to prices but no evidence for the opposite causality. Thus, the results add the empirical support to the argument in the literature that inflation is a monetary phenomenon.

Using time series data from 1960 to 2008 Climobi and Uche (2010) found that M2 has a strong unidirectional causal effect on the real output as well as on prices. Majid (2007) also found similar result for Malaysian economy. Yadav (2009) examined co-integration and causality between money and income for the Indian economy. Using the data for the period 1950-51 to 2006-07, the study found bidirectional causality between GNP and money supply. Psaradakis *et al.*, (2002) applied different econometric techniques to examine the money output relationship. Using a VAR model with time varying parameters for the U.S. data for the period 1959:1 to 2001:2, the paper found that causality relationship between money and output changes over time.

As to the empirical evidence on Bangladesh, there are some studies (Jones and Sattar 1988, Chowdhury *et al.* 1995, Ahmed 2000) which linked money, prices, income and interest rate. However, there is no substantial study using appropriate econometric methodology considering the time series properties of data. To the best of our knowledge, no study has been conducted to look into long-run causal relationship among Gross Domestic Product (GDP), Money supply (M2) and the Price level (CPI) in the context of Bangladesh. This paper seeks to redress this gap by examining the short-run and long-run causality between money, price and output. Moreover, this study is an improvement over the existing studies as it examined the stationarity of the data and applied co-integration and error correction approach to understand the short-run implication of the long-run relationship among the considered variables.

Data and Methodology

This paper investigates the dynamics of the short-run and long-run relationship among money, price and output in the context of Bangladesh for the period 1974 to 2012. The study uses annual data for the variables- Money Supply (M2), Consumer Price Index (CPI), and output provided by Real Gross Domestic Product (RGDP). The data on money supply and real GDP are collected from World Development Indicators (World Data Bank Online Version) for the period 1974 to 2012. Both variables are measured in Bangladeshi taka (million). Data on CPI for the period 1974 to 2012 are collected from various issues of Bangladesh Bureau of Statistics published by the Ministry of Planning, Bangladesh. All the considered variables are transformed into their natural logarithms and denoted as LCPI, LRGDP and LM2.

The estimation methodology employed in this study is the co-integration and error correction modeling techniques. The entire estimation procedure consists of three steps: first, unit root test; second, co-integration test; and third, the error correction estimation.

4.1 Unit Root Test

In the time series econometric methodology, a stationarity property of each time series under consideration is required to examine. In the present study, Augmented Dickey-Fuller (ADF) unit root test is employed to examine the stationarity of the data series. It is performed by running a regression of the first difference of the series against the series lagged once, lagged difference terms and, optionally a constant and a time trend. This can be expressed as follows:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \alpha_2 Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The purpose of inclusion of additional lagged terms is to ensure that the errors are uncorrelated. In this ADF procedure, the test of unit root is conducted on the coefficient of Y_{t-1} in the regression. If the coefficient is significantly different from zero, then the hypothesis that Y_t contains a unit root is rejected. Rejection of the null hypothesis implies stationarity. Precisely, the null hypothesis is that the variable Y_t is a non-stationary series (H_0:α_2=0) and is rejected when α_2 is significantly negative (H_A:α_2<0)

The decision about the stationarity of data series is taken by comparing the ADF values with McKinnon's critical values. If the calculated value of ADF statistic is higher than McKinnon's critical values, then the null hypothesis (H_0) is not rejected and the series is non-stationary. Failure to reject the null hypothesis leads to conducting the test on the difference of the series, so further differencing is conducted until stationarity is reached and the null hypothesis is rejected. If the time series (variables) are non-stationary in their levels, they can be integrated with I (1), when their first differences are stationary.

4.2 Co-integration Test

Once the unit root test is performed, a co-integration test is pursued in the next step to examine whether there exists a long-run equilibrium relationship among the variables. The existence of long-run equilibrium (stationary) relationships among economic variables is referred to in the literature as co-integration, which is very significant in avoiding the risk of spurious regression. The Johansen procedure (Johansen, 1991), which is a VAR approach, is employed in examining the existence of co- integration and provides not only an estimation methodology but also explicit procedures for testing for the number of co-integrating vectors as well as for restrictions suggested by economic theory in a multivariate setting. Engel and Granger (1987) pointed out that a linear combination of two or more non-stationary variables may be stationary. If such a stationary combination exists, then the non-stationary time series are said to be co-integrated. The VAR is based on co-integration test using the methodology developed in Johansen (Johansen, 1991). Johansen's methodology takes its starting point in the vector auto-regression (VAR) of order p given by

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + A_p y_{t-p} + \varepsilon_t \quad \ldots\ldots (2)$$

Where, is an n×1 vector of variables that are integrated of same order commonly denoted by I(t) and is an nx1 vector of innovations. Thus, VAR can be rewritten as

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta y_{t-1} + \varepsilon_t \quad \ldots\ldots (3)$$

Where, $\pi = \sum_{i=1}^{p} A_i - I$ *and* $\tau_i = \sum_{j=i+1}^{p} A_j$

To determine the number of co-integrating vectors, Johansen (1988, 1989), and Johansen and Juselius (1990) suggested two statistic tests, viz., the trace test statistic, and the maximum eigenvalue test statistic.

A. Trace Test Statistic and Maximum

The trace statistic is used to examine the number of co-integrating equation(s) which confirm us whether there is long run relationship among variables. In the trace test, the null hypothesis of r = 0 is tested against the alternative of r +1 co-integrating vectors. The trace test statistic can be specified as:

$$\tau_{trace} = -T \sum_{i=r+1}^{k} \log(1-\lambda_i)$$

Where, λ_i is the i^{th} largest eigenvalue of matrix $\prod$ and T is the number of observations? In the trace test, the null hypothesis assumes that the number of distinct co-integrating vector(s) be less than or equal to the number of co-integration relations (r).

B. Maximum Eigenvalue Test

The maximum Eigenvalue test examines the null hypothesis of exactly r co-integrating relations against the alternative of r+1 co-integrating relations with the test statistic:

$$\tau_{trace} = -T \log(1-\lambda_{r+1})$$

Where λ_{r+1} is the $(r+1)^{th}$ largest squared Eigenvalue.

It is well known that Johansen's co-integration test is very sensitive to the choice of lag length. Therefore, a VAR model is fitted first to the time series data in order to find an appropriate lag structure. The Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and the Likelihood Ratio (LR) test are used to select the number of lags required in the co-integration test.

4.3 Vector Error Correction Model (VECM)

If co-integration is confirmed to exist between variables, then it requires the construction of error correction mechanism to model dynamic relationship among

the series. The purpose of the error correction model is to indicate the speed of adjustment towards long-run equilibrium. A Vector Error Correction Model (VECM) is a restricted VAR designed for use with non-stationary series that are known to be co-integrated. Once the equilibrium conditions are imposed, the VECM describes how the examined model is adjusting in each time period towards its long-run equilibrium state. Since the variables are supposed to be co-integrated, then in the short-run, deviations from this long-run equilibrium will feedback on the changes in the dependent variables in order to force their movements towards the long-run equilibrium state. Hence, the co-integration vectors from which the error correction terms are derived are each indicating an independent direction where a stable meaningful long-run equilibrium state exists. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustment. In this study, the error correction model as suggested by Hendry has been used. The general form of the VECM is as follows:

$$\Delta X_t = \alpha_0 + \lambda_1 EC^1_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta X_{t-i} + \sum_{j=1}^{m} \alpha_j \Delta Y_{t-j} + \varepsilon_{1t} \quad \text{.....(4)}$$

$$\Delta Y_t = \beta_0 + \lambda_2 EC^2_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{j=1}^{m} \beta_j \Delta X_{t-j} + \varepsilon_{2t} \quad \text{.....(5)}$$

Where, Δ is the first difference operator; EC_{t-1} is the error correction term lagged one period; λ is the short-run coefficient of the error correction term ($-1 < \lambda < 0$); and ε is the white noise error term. The error correction coefficient (λ) is very important in this error correction estimation as greater the co-efficient indicates higher speed of adjustment of the model from the short-run to the long-run. The error correction term represents the long-run relationship. A negative and significant coefficient of the error correction term indicates the presence of long-run causal relationship. If the both the coefficients of the error correction terms in both the equations are significant, this will suggest the existence of bi-directional causality. If only λ_1 is negative and significant, this will suggest a unidirectional causality from Y to X, implying that Y drives X towards long-run equilibrium but not the other way around. Similarly, if λ_2 is negative and significant, this will suggest a unidirectional causality from X to Y, implying that X drives Y towards long-run equilibrium but not the other way around.

The lagged terms of ΔX_t and ΔY_t appeared as explanatory variables in the VECM, indicate short-run cause and effect relationship between the two variables. Thus, if the lagged coefficients of ΔX_t appear to be significant in the regression of ΔY_t, this will mean that X causes Y. Similarly, if the lagged coefficients of ΔY_t appear to be significant in the regression of ΔX_t, this will mean that Y causes X.

5. Empirical Analysis

In time series analysis, it is required to test the stationary property for all considered variables at the first step. Therefore, the Augmented Dickey-Fuller unit

root test has been employed to check the stationary property of the data series-money supply (M2), price level (CPI) and real GDP (RGDP), and the results are represented in Table 1.

Table 1: Results of Augmented Dickey Fuller Unit Root Test at Levels and at First Difference of the Variables (1974-2012)

Variables	Level	1st Differences	MacKinnon Critical Values for Rejection of Hypothesis of a Unit Root		
			1%	5%	10%
LCPI	-2.133942	-4.991777	-3.632900	-2.948404	-2.612874
LM2	-1.902950	-4.243754	-3.632900	-2.948404	-2.612874
LRGDP	-1.459870	-3.733942	-3.632900	-2.948404	-2.612874

Table 1 shows that all the variables are non-stationary at levels. This can be verified by comparing the results of ADF test statistics (in absolute terms) with the critical values (also in absolute terms) of the test statistics Asian Review Vol. 4, No. 1, 2015

at 1%, 5% and 10% level of significance. Since the absolute values of ADF test statistic are lower than the absolute critical values at 1%, 5% and 10% level of significance, therefore, the null hypothesis is accepted and there is unit root problem in the variables at level. On the other hand, all three variables are stationary at first difference because the absolute values of ADF test statistic are greater than the critical values at 1%, 5% and 10% levels of significance. Thus, the variables are integrated of order one, i.e. I (1).

Table 2: Results of Johansen's Cointegration Test

Hypothesized Number of Cointegrating Equations	Eigen Value	Trace Statistic	Critical Value at 5%	Maximum Eigen Statistic	Critical Value at 5%
None*	0.4832	33.05	29.68	23.10	20.97
At Most 1	0.1989	9.94	15.41	7.76	14.07
At Most 2	0.0604	2.18	3.76	2.18	3.76

*Denotes rejection of the hypothesis at the 5% level of significance

In the next step, we investigate the existence of any unique equilibrium relationship(s) among the stationary variables of the same order of integration. The Johansen VAR based methodology approach has been used for this purpose. The results based on VARs are sensitive to the lag length and this compelled us to devote a considerable time to the selection of the lag structure. The selected lag length(s) are those that reduce autocorrelation in the model. In the present study,

the appropriate lag is 2 which is chosen by minimizing the Akaike Information Criterion (AIC). The results of Johansen's co-integration test are presented in Table 2. The results of Trace test indicate the existence of one co-integrating equation at 5% level of significance and the Maximum Eigen value test makes the confirmation of this results. Thus, the two variables have long-run equilibrium relationship between them.

However, in the short-run there may be divergences from this equilibrium. Therefore, it is necessary to verify whether such disequilibrium converges to the long-run equilibrium or not. Vector Error Correction Model is used to make sure this short-run dynamics. Error correction mechanism provides a rate of adjustment at which disequilibrium is corrected in the next period. The results of error correction model with the computed *t* values of the regression coefficient are presented in Table 3.

Table 3: Estimation of Error Correction Model

Dependent Variable: LM2t Independent Variable: LCPIt and LRGDPt							
EC^1t-1	ΔLM2t-1	ΔLM2t-2	ΔLCPIt-1	ΔLCPIt-2	ΔLRGDPt-1	ΔLRGDPt-2	Constant
-0.087*	-0.142	-0.487*	0.176*	0.179	-0.276	0.009	0.190*
(-4.048)	(-0.687)	(-2.823)	(3.192)	(0.767)	(-0.562)	(0.039)	(4.648)
Dependent Variable: LCPIt Independent Variable: LM2t and LRGDPt							
EC^2t-1	ΔLM2t-1	ΔLM2t-2	ΔLCPIt-1	ΔLCPIt-2	ΔLRGDPt-1	ΔLRGDPt-2	Constant
-0.178	0.776*	0.393*	0.068	-0.035	0.741*	0.672*	0.049*
(-1.585)	(3.412)	(2.658)	(0.981)	(-0.375)	(2.915)	(3.007)	(2.985)
Dependent Variable: LRGDPt Independent Variable: LM2t and LCPIt							
EC^3t-1	ΔLM2t-1	ΔLM2t-2	ΔLCPIt-1	ΔLCPIt-2	ΔLRGDPt-1	ΔLRGDPt-2	Constant
-0.037*	-0.192	-0.587	-0.227	-0.005	0.997*	-0.199	0.020
(-3.741)	(-0.304)	(-1.116)	(-1.165)	(-0.011)	(2.667)	(-0.339)	(0.965)
Note: Figures in the parentheses indicate t-statistic							

It is observed that the estimated coefficient of error-correction term in the LM2 equation is negative and statistically significant at 1% level. This indicates that there is a long-run equilibrium relation between the dependent and independent variables, and its relative value (-0.087) for Bangladesh shows the rate of convergence to the equilibrium state per year. This result shows that the speed of adjustment between short-run and long-run disequilibrium is 8.7% in money supply in each year. In the second equation, i.e., in LCPI equation, the estimated

coefficient of the error term is negative but not statistically significant. It means that the error term has no contribution in explaining the changes in price level. However, in the LRGDP equation, the estimated coefficient of the error term is negative and statistically significant at 1% level. As a result, the error term is able to explain the changes in output. Furthermore, the existence of co-integration implies the existence of Granger causality at least in one direction (Granger, 1988). The negative and statistically significant value of the error correction coefficient indicates the existence of a long-run causal relationship between the variables. Table 3 shows that, there exist bi-directional causalities between money supply and output, but unidirectional causalities from price to money supply and price to output in the long-run.

In LM2 equation, the coefficient of the first difference of LCPI is statistically significant, indicating the existence of short-run causality from price level to money supply. In LCPI equation, the coefficient of LM2 lagged one period and the coefficient of LRGDP lagged two periods are statistically significant. This result indicates the existence of short-run causality from money supply to price level and from output to price level. However, in LRGDP equation, no such causality is found. In order to verify the result of short-run causality among ΔLM2, ΔLCPI and ΔLRGDP based on VECM estimates, a standard Granger causality test has also been run based on F-statistic.

Table 4 reports the Granger causality results for the variables LM2, LCPI, and LRGDP. The results indicate that in the case of LCPI and LM2, at 1% level of significance, the null hypothesis of ΔLCPI does not Granger cause ΔLM2, and Δ LM2 does not Granger cause ΔLCPI are rejected. Thus, these results support that there exist a bi-directional causality between money supply and price level in the short-run. Again, the null hypothesis of ΔLRGDP does not Granger cause ΔLM2, and ΔLM2 does not Granger cause ΔLRGDP are accepted. It indicates that there exists no short-run causality from output to money supply or from money supply to output. Furthermore, the null hypothesis of ΔLRGDP does not Granger because Δ LCPI is rejected at 1% level of significance while the null hypothesis of ΔLCPI does not Granger Cause ΔLRGDP cannot be rejected. This result indicates that there is a unidirectional causality from output to price level. These results support the previous results obtained from VECM about the existence of short-run causality.

Table 4: Results of Granger Causality Test

Null Hypothesis	F-Statistic	Probability	Decision
ΔLCPI does not Granger Cause ΔLM2	4.60948	0.01796	Rejected
ΔLM2 does not Granger Cause ΔLCPI	12.4794	0.00011	Rejected
ΔLRGDP does not Ganger Cause ΔLM2	1.67302	0.20472	Accepted
ΔLM2 does not Granger Cause ΔLRGDP	0.43672	0.65020	Accepted
ΔLRGDP does not Granger Cause ΔLCPI	4.83313	0.01515	Rejected
ΔLCPI does not Granger Cause ΔLRGDP	0.00479	0.92799	Accepted

(Number of Appropriate Lags = 2)

Based on the co-integration and causality tests, it can be said that change in the money supply and change in output causes each other in the long-run. Secondly, change in price level causes change in money supply both in the short- and long-run. Thirdly, change in the price level causes change in output in the long run but not in short-run. In the short-run, change in output causes change in price level.

Summary and Conclusion

The present study is an attempt to analyze the causal relationships among money supply, price level and output in the context of Bangladesh employing time series analysis techniques for the period 1974-2012. The stationary test performed by the Augmented Dickey-Fuller unit root test indicates that all the three data series are non-stationary at level but stationary at first difference. That is, the data series are I(1). Using the Johansen's co-integration test procedure one co-integrating equation is found which means that the variables have a long-run equilibrium relationship among them, although they have disequilibrium in the short-run. The estimation results from vector error correction model implies the existence of long-run bi-directional causality between money supply and output while unidirectional causality is found from price level to money supply, and price level to output. However, the Granger causality test shows that in the short-run, bi-directional causality exists between money supply and price level, and unidirectional causality exists from output to price level. The long-run bidirectional causality between money supply and output confirm that money is not neutral in its effect and thus, disproves the Keynesian belief and supports the Monetarists view. In addition, the evidence of short-run bidirectional causality between money supply and price level indicates that inflation is a monetary phenomenon in the short-run only. This evidence regarding the short-run dynamics adjustment among money supply and price level indicates that active monetary policy to stabilize short-run fluctuation in prices must be handled with caution, as it would increase price fluctuations in the long-run. Moreover, the effective coordination between monetary and fiscal policy would enable to achieve price stability within the environment of high and sustainable economic growth.

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