*Pakistan Economic and Social Review*
Volume XLIII, No. 1 (Summer 2005), pp. 1-20

# EQUILIBRIUM VERSUS DISEQUILIBRIUM THEORIES OF BUSINESS CYCLES
## Evidence from Pakistan Economy

MUHAMMAD ASLAM CHAUDHARY
MUNIR A. S. CHOUDHARY and MEHAK EJAZ*

**Abstract.** This paper tests the Keynesian, monetary and real business cycle theories using annual data from Pakistan covering period 1953-2004. An error-correction equation to explain inflation is presented that passes the Chow test for parameter stability and fits the data well. Based on this error- correction equation a vector error correction model is estimated to provide evidence on the dynamics between prices, money, interest rates and real output. Variance decomposition and impulse responses from this vector-error correction model support the disequilibrium (Keynesian) business cycle theory which claims that effects of monetary shocks on real output do not die down quickly.

## I. INTRODUCTION

Early economists believed that each cyclical phase of the economy carries within it the seeds that generate the next cyclical phase. An upturn in economic activity generates the next downturn and that in turn leads to next expansion; thus, the economy is caught forever in a self generating cycle. In contrast, modern theories of business cycles attribute cyclical fluctuations to shocks and disturbances that continually take place in the economy. In other words, there are no cycles without shocks. This shift in views regarding the causes of business cycles is an important development in macroeconomics and especially significant for policy making institutions like the central banks. The view that cycles are self generating implies that market economies cannot deliver stable economic performance over a longer period of time and thus discretionary policies should be used to eliminate or reduce

*The authors are, respectively, Professor and Chairman, Foreign Professor and Research Assistant at the Department of Economics, University of the Punjab, Lahore-54590 (Pakistan).

the severity of cycles. On the other hand, the view that shocks are the cause of cycles does not point out to a particular policy stance. If shocks can be eliminated then discretionary policy should be followed because more stable economy means less cycles. However, if shocks cannot be eliminated then discretionary policy should not be adopted because it might do more harm than good by destabilizing the economy and generating more cycles.

At present, almost all macroeconomists agree that business cycles are generated by shocks; however, there is considerable debate on the nature of shocks that generate business cycles. The shock based theories can be classified into two groups: disequilibrium theories and equilibrium theories.

Disequilibrium theories also known as Keynesian theories of business cycle view wages and price rigidities as the main cause of business cycles (Fischer, 1977; Taylor, 1980). Let us briefly consider Keynesian Business Cycle (KBC) theory in terms of aggregate demand (AD) and aggregate supply (AS) framework. The important issue in KBC theory is not the source of shocks or the transmission mechanism, but how the economy responds to these shocks. Consider a decline in the money supply which shift AD curve to the left. In the short-run, the prices being fixed the AS curve is perfectly elastic. Thus, leftward shift in the AD curve moves the economy to the lower level of output. Eventually downward pressure on prices would move the economy back to its natural rate at lower prices. Thus, according to KBC, changes in money stock, whether anticipated or unanticipated have their greatest short-run effect on real output and employment not on prices. A fundamental proposition of KBC is that effects on output do not die quickly; the process may take an unacceptable long period of time. Keynesian believes short-run lasts long enough to matter. Another point of the KBC theory is that money supply is determined endogenously by money income and hence output and inflation leads money changes.

Equilibrium business cycle theories consider short-run fluctuation in output to be consistent with a state of equilibrium. Depending on whether they emphasize monetary or real shocks as the major source of cyclical change, these theories can be divided into monetary business cycle (MBC) and real business cycle (RBC) theories.

Monetary theories include the monetarists and the rational expectations or new classical models. Friedman (1968) and Phelps (1969) independently altered the Walrasian model to provide the monetarist theory of output determination, which could account for the observed short-run fluctuations in output. In the Walrasian model, where all agents possess complete information, the assumption of complete flexibility of wages and prices assures that increase in the general price level will be unable to create dispersion between the actual and anticipated real wages. Thus, the effect of a price increase in the Walrasian model will be a proportionate increase in nominal wage, leaving real wages, employment and output unchanged. Friedman–Phelps retained the Walrasian assumption of complete flexibility of wages and prices but the assumption that all agents possess complete information. In their model, price level is perfectly perceived by producers but not by workers. Producers use current price to evaluate real wages and workers use perceived price level (adaptive expectation) to evaluate real wages. An increase in price level will lower the real wage and this will increase the demand for labor. The nominal wage rate will increase. Because the increase in the price level is not fully perceived by workers, they interpret the increase in nominal wage rate as increase in real wage rate, and therefore the supply of labor will increase. This will increase employment and output above full employment level. In the long-run, workers perceived price level and actual price level will be same and the employment and output will be back at its full employment level.

Neo Classical (Lucas, 1972; 1973) is an improvement on the Friedman-Phelps model, in which assumption of asymmetry of information is replaced with symmetry of information for all economic agents and the assumption of adaptive expectation is replaced with rational expectation. This model is based on the assumption that individuals have imperfect information regarding prices. According to Lucas, a producer's decision to change output level depends on the change in relative price not on the change in the general price level. If the change in the price of his product is due to the change in the general price level, it does not pay him to change the output level because the real wage and real profit remains unchanged. In this model, if the increase in the general price level is perfectly anticipated it has no effect on employment and output. However, an unanticipated increase in the general price level is confused with the relative price increase that leads to temporarily change in output from its full employment level.

The essence of MBC theory is that money supply is exogenously determined and when money supply increases, real output will increase more rapidly than price level increases but real output will die down more rapidly than prices.

In RBC theory, the residual that generates business cycle is the deviation of labor productivity from its model predicted value. The model used in RBC theory holds that average labor productivity is positively related to the amount of capital per worker in the economy. The difference between growth in actual labor productivity and its model predicted value is called the Solow residual, named after Robert Solow, who developed this idea. A positive Solow residual indicates an improvement in the economy's technological capability brought by new inventions. In RBC theory, fluctuations in Solow residual are seen as a major cause of business cycles (Kydland and Prescott, 1982; King and Plosser, 1984). For example, when Solow residual rises above its normal level, the firms are motivated to invest in new plant and equipments to take advantage of new and improved technology. To meet the increased demand for investment goods, firms demand more workers that cause rise in real wages. Because of intertemporal substitution of labor, higher real wages leads to greater employment and output. Similarly, RBC theorists explain recessions as periods in which Solow residual fall below normal level because of technological regress. This leads to lower demand for capital goods, the demand for labor and real wages fall which reduces the incentive to work, causing employment and output to fall.

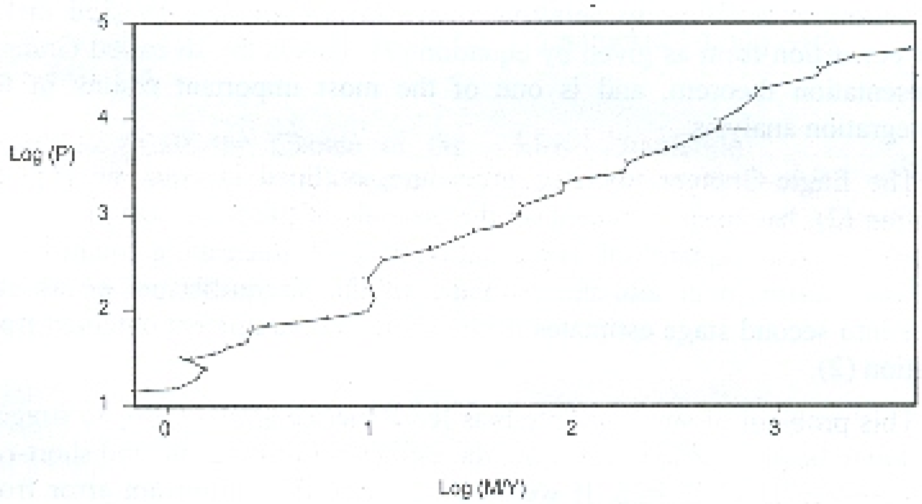
In contrast to both KBC and MBC theories, RBC theory embraces the classical dichotomy. It accepts the complete neutrality of money, even in the short-run. That is nominal variables, such as money supply and price level, are assumed to have no effect on real variables such as output and employment. According to RBC theorist, money supply is endogenous; fluctuation in output causes fluctuation in money supply. For example, fluctuations in output due to technological shocks cause fluctuations in the demand for money and thus fluctuations in the interest rates. The monetary authorities, in attempt to reduce the fluctuations in interest rates, respond by changing the money supply to accommodate the money demand. Thus, endogenous response of money to business cycles gives the illusion that business cycles are caused by monetary shocks.

Since the development of these theories, a number of empirical studies have emerged that are mainly concerned with testing them for developed countries. Recent studies by Sims (1980; 1992), Bernanke and Blinder (1992), Thoma (1994) and Cook (1999) among others have provided mixed empirical results. Very little work has been done to test the validity of these theories for developing countries. The purpose of this paper is to test the validity of the KBC, MBC and RBC theories, using data from a developing economy like Pakistan.

The remainder of the paper is organized as follows. In section II we develop an error-correction model to explain inflation in Pakistan. In section III test results for cointegration, unit roots and estimates of error-correction model are presented. In section IV variance decompositions and impulse responses are calculated from vector error-correction model and the results are discussed to see which business cycle theory is supported by Pakistani data. Section IV concludes the paper.

## II. AN ERROR-CORRECTION MODEL TO EXPLAIN INFLATION IN PAKISTAN

In business cycle models the price level represents a basic variable, because prices adjust to clear money and output markets. To study the behavior of price level in Pakistan, we consider a weak form of the quantity theory of money because the strong functional form of the quantity equation $MV = PY$ may not be correct empirically. The weak functional form states that velocity ($V$) depends on the interest rate and may not be constant even in the long run. Furthermore, if the equation is expressed as demand for money equation ($M/P = Y/V$), the income elasticity of unity may not be correct empirically. Thus, in weak functional form, with output ($Y$) held constant, price level ($P$) tends to increase as money supply ($M$) increases, with $M$ held constant tends to increase as $Y$ decreases; and with $P$ held constant, $Y$ tends to increase as $M$ increases.




The error-correction inflation model has two parts. The first is long-run equilibrium relationship. Figure 1 plots log ($P$) against log ($M/Y$) over the entire sample period.

Overall, the plot suggests that in long-run, the relationship between log ($P$) and log ($M/Y$) is approximately linear. We specify the following long run equilibrium price level function.

$$\log(P_t) = \alpha_0 + \alpha_1 \log(M_t) + \alpha_2 \log(Y_t) + \alpha_3 \log(R_t) + u_t \qquad (1)$$

We have added the interest rate variable ($R_t$) because change in the interest would affect the price level through its effect on the velocity of money. The parameters $\alpha_1$, $\alpha_2$ and $\alpha_3$ measure, respectively, the long-run money, income and interest rate elasticities. $u_t$ is the long run random disturbance term.

The second part of the model is a dynamic error-correction equation of the following form:

$$\Delta\log(P_t) = \beta_0 + \sum_{i=1}^{n1} \beta_{1i}\Delta\log(P_{t-i}) + \sum_{i=0}^{n2} \beta_{2i}\Delta\log(M_{t-i}) + \sum_{i=0}^{n3} \beta_{3i}\Delta\log(Y_{t-i}) + \sum_{i=0}^{n4} \beta_{4i}\Delta\log(R_{t-i}) + \lambda u_{t-1} + \varepsilon_t \qquad (2)$$

where $\varepsilon_t$ is the short-run random disturbance term; $\Delta$ is the first difference operator; $n_i$ = number of lags, $u_{t-1}$ is the lagged value of the long-run random disturbance term.

According to Engle and Granger (1987), if variables in equation (1) are integrated of order one I (1) and cointegrated, then the short-term disequilibrium relationship between them can always be expressed in the error correction form as given by equation (2). This is the so-called Granger representation theorem, and is one of the most important results in the cointegration analysis.

The Engle-Granger two-step procedure, outlined in equation (1) and equation (2), has been criticized on the grounds of the small sample bias in the ordinary least square (OLS) estimation of the cointegrating equation (1). This bias carries over into the estimates of the disequilibrium errors and hence into second stage estimates of the short-run parameters obtained from equation (2).

This problem of small sample bias led Banerjee *et al.* (1986) to suggest that it may be preferable to carry out the estimation of long-run and short-run parameters in a single step. If we substitute true disequilibrium error from equation (1) into equation (2), we obtain a combined equation:

$$\Delta\log(P_t) = \delta_0 + \sum_{i=1}^{n1} \beta_{1i}\Delta\log(P_{t-i}) + \sum_{i=1}^{n2} \beta_{2i}\Delta\log(M_{t-i}) + \sum_{i=0}^{n3} \beta_{3i}\Delta\log(Y_{t-i}) + \sum_{i=1}^{n4} \beta_{4i}\Delta\log(R_{t-i}) + \delta_1 \log(P_{t-1}) + \delta_2 \log(M_{t-1}) + \delta_3 \log(Y_{t-1}) + \delta_4 \log(R_{t-1}) + \varepsilon_t \qquad (3)$$

where: $\delta_0 = \beta_0 - \lambda\alpha_0$, $\delta_1 = \lambda$
$\delta_2 = \lambda\alpha_1$, $\delta_3 = \lambda\alpha_2$, $\delta_4 = \lambda\alpha_3$

Although $\log(P_{t-1})$, $\log(Y_{t-1})$, $\log(M_{t-1})$ and $\log(R_{t-1})$ are I (1) variables, OLS estimation procedure can still be applied, since, assuming cointegration, there is a linear combination of these variables that is stationary I (0). Thus, consistent estimates of equation (3) can be obtained using OLS method and all parameters of equation (1) and equation (2) can be recovered from equation (3). For example, the error correction coefficient $\lambda = \delta_1$; the long run effect of 1% change in money supply on the price level is measured by $\alpha_1 = -(\delta_2 / \delta_1)$; the long-run effect of 1% change in real output on price level is $\alpha_2 = -(\delta_3 / \delta_1)$; and the long run effect of 1% change in the interest rate on price level is $\alpha_3 = -(\delta_4 / \delta_1)$.

## III. TEST FOR COINTEGRATION

To get reliable estimates of equation 3, the implicit assumption is that variables in equation (1) are I (1) and cointegrated, hence, we must first test whether the variables included in equation (1) are non-stationary and cointegrated. Two tests for cointegration have been posed in the literature, Engle and Granger (1987) and Johansen and Juselius (1990). In the multivariate case, if I (1) variables are linked by more than one cointegrating vectors then the Engle-Granger procedure is not applicable. The test for cointegration used here is the likelihood ratio test as proposed by Johnasen and Juselius (1990). This method involves estimating the following unrestricted vector autoregressive (VAR) model:

$$X_t = b + \sum_{j=1}^{p} A_j X_{t-j} + \varepsilon_t \qquad (4)$$

where $X_t$ is a $k$ vector of I (1) variables, in our case $X_t \equiv [\log(P_t), \log(M_t), \log(Y_t), \log(R_t)]$, $k$ is the number of variables in the system, four in our case, $b$ is $k \times 1$ vector of constants, $P$ is the number of lags, $A_j s$ are $k \times k$ matrices of coefficients to be estimated. $\varepsilon_t$ is a $k \times 1$ vector of Gaussian errors. If $X_t$ is cointegrated, it can be transformed into a vector error correction form:

$$\Delta X_t = b + \sum_{j=1}^{p-1} \Gamma_j \Delta X_{t-j} + \Pi X_{t-1} + \varepsilon_t \qquad (5)$$

where $\Gamma_j = -\sum_{i=j+1}^{p} A_i$ and $\Pi = \sum_{j=1}^{p} A_j - I$

I is a $k \times k$ identity matrix and Δ is the difference operator.

According to the Granger representation theorem, if Π has a reduced rank $r < k$, then there exist $k \times r$ matrices such that $\Pi = \alpha \beta$, where $\alpha$ represents the speed of adjustment to disequilibrium while $\beta$ is a matrix of long-run coefficients. Thus, the term $\beta' X_{t-1}$ is equivalent to the error-correction term. Johansen's approach centers on estimating the matrix Π in an unrestricted form, and then testing whether the restrictions implied by the reduced rank of Π can be rejected.

The number of the independent cointegrating vectors depends on the rank of Π, which in turn is determined by the number of its characteristic roots that differ from zero. Johansen provides two different test statistics to test for the nonzero characteristic roots, the trace test and the maximum eigenvalue test. The trace test statistic ($\lambda_{trace}$) tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against the alternative hypothesis of more than $r$ cointegrating vectors. The trace test statistic is defined as:

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

where $T$ is the number of usable observations and $\lambda's$ are the eigenvalues of Π. The maximum eigenvalue test statistics ($\lambda_{max}$) tests the null hypothesis that the number of distinct cointegrating vector is $r$ against the alternative hypothesis of $r + 1$ cointegrating vectors. The maximum eigenvalue test statistic is defined as:

$$\lambda_{max} = (r, r+1) = -T \ln(1 - \lambda_{r+1})$$

Johansen and Juselius (1990) provide critical values for the two statistics. The statistical distribution depends on the number of non-stationary components and model setting of drift and trend term. To determine the non-stationary components, it is necessary to choose the length of lags for the VAR portion of the model. We use the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC) to select the lag length of the VAR system. The lowest values of AIC or SBC to select the lags gives the most desirable model.

## DATA AND DEFINITION OF VARIABLES

The data used are annual and cover the time period from 1953 through 2003. Real GDP (Y) is used as a proxy for output. M is narrow definition of nominal money stock. The price level (P) is measured by the GDP deflator.

The short term interest rate (R) is measured by call money rates. Data on all variables are taken from International Financial Statistics, online service.

## UNIT ROOT TEST RESULTS

Inflation equation (3) includes the levels and first differences of the price level, money supply, real output and interest rate. To test for stationarity in these variables, we use Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit-root tests. The results are reported in Table 1. The ADF test is performed by estimating the following equation with and without trend variables ($t$):

$$\Delta X_t = \beta_0 + \beta_1 t + \delta X_{t-1} + \alpha_i \sum_{i=1}^{n} \Delta X_{t-i} + \varepsilon_t \quad (6)$$

The number of lagged differenced terms ($n$) is determined by Akaike Information Criterion (AIC). After estimating the equation, we test the hypothesis whether $\delta = 0$.

TABLE 1

Unit Root Test Results, 1953-2003

| Variable ($X_t$) | ADF Test | | PP Test | |
|---|---|---|---|---|
| | Without trend | With Trend | Without Trend | With Trend |
| Log(P) | 0.064 | –2.50 | 1.02 | –2.37 |
| Log(M) | 1.57 | –2.21 | 1.83 | –2.21 |
| Log(Y) | 0.31 | –1.74 | 0.61 | –2.04 |
| Log(R) | –2.15 | –0.35 | –2.42 | –0.47 |
| Δlog(P) | –3.76* | –3.66* | –3.51* | –3.56* |
| Δlog(M) | –4.43* | –5.01* | –5.91* | –6.33* |
| Δlog(Y) | –4.36* | –4.29* | –6.81* | –6.77* |
| Δlog(R) | –3.97* | –4.99* | –5.39* | –6.15* |

Notes: 5% critical value is –3.5.
*indicates significant at 5% level.

In ADF test, lagged difference terms are included to remove possible serial correlation in the error terms. The PP test uses nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged differenced terms.

The results presented in Table 1 show that null hypothesis of unit-root ($\delta = 0$) cannot be rejected for any variable in the level form. However, the null hypothesis of unit-root is rejected for all variables in the first differenced form at 5% level. Thus, our test results show that all variables are I (1).

## COINTEGRATION TEST RESULTS

The unit root test results presented above imply that all variables are I (1). If variables in equation (1) are cointegrated, then equation (3) can be estimated by ordinary least square and estimated parameters are not subject to spurious regression phenomenon.

Before we run cointegration test, we need to specify the lag structure. This is important because a lag structure which is too high may over parameterize and, therefore, reduce the power of cointegration test. However, if the lag structure is too short it may not produce the residuals which are white noise. In order to investigate the optimal lag structure both Akaike Information criterion (AIC) and the Schwarz Bayesian Criterion (SBC) for various lags (1-4) were performed. The results suggested a lag of (1).

TABLE 2

Johansen Cointegration Tests

Series: log (P), log (M), log (Y) and log (R)

| Null | Alternative | Eigenvalue | $\lambda_{trace}$ test | $\lambda_{max}$ test | Critical value | |
|---|---|---|---|---|---|---|
| | | | | | 5% | 1% |
| $r = 0$ | $r > 0$ | 0.510 | 56.46* | | 47.21 | 54.46 |
| $r \leq 1$ | $r > 1$ | 0.285 | 21.48 | | 29.68 | 35.65 |
| $r \leq 2$ | $r > 2$ | 0.086 | 5.01 | | 15.41 | 20.04 |
| $r \leq 3$ | $r > 3$ | 0.011 | 0.58 | | 3.76 | 6.65 |
| $r = 0$ | $r = 1$ | 0.510 | | 34.98* | 27.07 | 32.24 |
| $r = 1$ | $r = 2$ | 0.285 | | 16.47 | 20.97 | 25.52 |
| $r = 2$ | $r = 3$ | 0.086 | | 4.43 | 14.07 | 18.63 |

Note: *denotes rejection of the hypothesis at 5% and 1% significance level.

In order to determine the number of significant cointegrating vectors, we use Johansen's test. We choose to include a linear trend in the data and a drift term but no trend in the cointegrating equation. Table 2 reports the $\lambda-\max$ and trace tests to identify the number of significant cointegrating vectors.

Both the $\lambda_{trace}$ and $\lambda_{max}$ tests support the hypothesis that there is one cointegrating relation among log ($P_t$), log ($M_t$), log ($Y_t$) and log ($R_t$).

## ESTIMATED ERROR-CORRECTION MODEL TO EXPLAIN INFLATION IN PAKISTAN

Our test results show that first differences of the variables in equation (3) are stationary but the levels of the variables are non-stationary. However, Johansen cointegration test shows one cointegrating relationship among the non-stationary variables in equation (3). Thus, equation (3) can be estimated using OLS method. The results of estimating equation (3) are as given below:

$$\begin{aligned}\Delta\log(P_t) = \; & \underset{(1.030)}{0.171} + \underset{(0.112)}{0.476}\,\Delta\log(P_{t-1}) + \underset{(0.068)}{0.209}\,\Delta\log(M_t) \\ & - \underset{(0.072)}{0.158}\,\Delta\log(M_{t-1}) - \underset{(0.139)}{0.177}\,\Delta\log(Y_t) + \\ & \underset{(0.142)}{0.350}\,\Delta\log(Y_{t-1}) + \underset{(0.017)}{0.071}\,\Delta\log(R_t) - \underset{(0.060)}{0.316}\,\log(P_{t-1}) \\ & + \underset{(0.056)}{0.305}\,\log(M_{t-1}) - \underset{(0.078)}{0.296}\,\log(Y_{t-1}) + \underset{(0.013)}{0.037}\,\log(R_{t-1}) \quad (7)\end{aligned}$$

$R^2 = 0.7359$, $\bar{R}^2 = 0.6664$, SER $= 0.026$, $\chi^2(1) = 0.33$, $\chi^2(2) = 2.82$

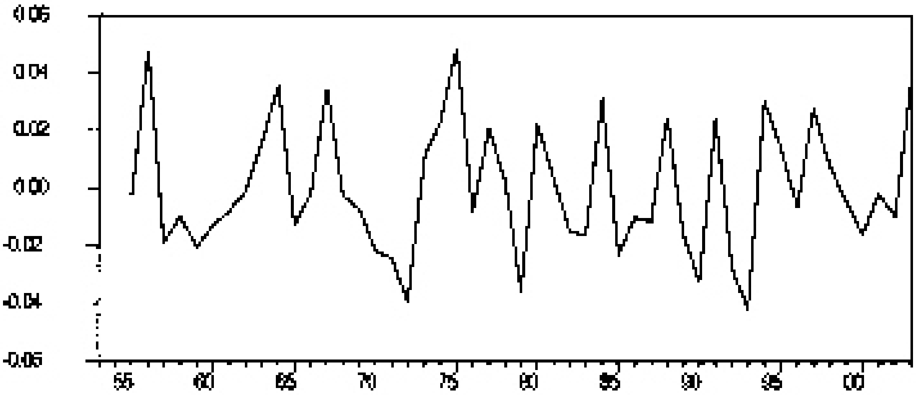
Standard errors of coefficients are in parentheses, $\chi^2$ (1) and $\chi^2$ (2) are Breusch-Godfrey LM test statistics for the presence of first and second-order correlation in residuals, respectively. The null hypothesis of no first-order or second-order serial correlation cannot be rejected at even 10% significance level.

As can be seen, estimated error-correction model of inflation provides reasonable point estimates of the short-run and long-run parameters. The quantity theory of money states that in the long-run the quantity of money has a direct and proportionate effect on the price level and the output has a negative and inversely proportionate effect on the price level. Our results show that long-run elasticity of the price level with respect to money supply is $0.305 / 0.316 = 0.965$. F-statistic for testing the null hypothesis that long-run elasticity of price level with respect to money supply is equal to 1 is 0.18, strongly supporting the hypothesis that long-run elasticity of price with respect to money supply is not different from 1. The long-run elasticity of price level with respect to real output is –0.296 / 0.316 = –0.937. The F-statistic for testing the null hypothesis that long-run elasticity of price level with respect to output is –1 is 0.08, strongly supporting the hypothesis that long-run elasticity of price level with respect to output is not different from –1. Thus, evidences presented from error-correction equation (3) shows remarkable support for the long-run proposition of the quantity theory of money for Pakistan.

The residuals of this error-correction model are plotted in Figure 2 to examine how well it explains the data.

FIGURE 2

Plot Residuals from Equation (7)




Examination of Figure 2 shows that residuals are small and do not exhibit above normal spikes in any time period. Thus, the error-correction model used in this study successfully explains the price increases as well as price decreases in Pakistan.

The parameters of the error-correction model are further evaluated for their structural stability. Table 3 presents results of the Chow test of structural stability over the period 1953 to 2003. The Chow test is implemented using the dummy variable technique and potential break points covering 1971 to 1980 are considered.

As can be seen in the Table 3, the F-statistics are quite low as compared with 5% critical value. Hence, the null hypothesis of parameter stability is easily accepted. The results of the stability test further support the validity of our error-correction model in explaining inflation in Pakistan.

TABLE 3

Stability Test, 1953-2003

| Break point | F-statistics | Break point | F-statistics |
|---|---|---|---|
| 1971 | 0.89 | 1976 | 0.96 |
| 1972 | 0.82 | 1977 | 0.92 |
| 1973 | 1.47 | 1978 | 0.84 |
| 1974 | 1.65 | 1979 | 0.84 |
| 1975 | 0.90 | 1980 | 0.92 |

Notes: The reported F-statistics test the null hypothesis that slope dummies when added to equation 3 are jointly insignificant. The dummies take values 1 for observations greater than the break point and zero otherwise. The critical values of F-statistics at 5% level is $F(11, 27) = 2.10$.

## IV. VECTOR ERROR CORRECTION MODEL

In this section, we estimate a VAR explaining the vector $\Delta X_t$ by $X_{t-1}$ and $\Delta X_{t-1}$. The vector $\Delta X_t$ include $\Delta \log(P_t)$, $\Delta \log(M_t)$, $\Delta \log(R_t)$ and $\Delta \log(Y_t)$. As the Johansen cointegration test shows one cointegrating vector, we estimate VEC model assuming one cointegrating relation, the normalized cointegrating equation is $\beta X_{t-1} = \log(P_{t-1}) - 0.98 \log(M_{t-1}) - 0.10 \log(R_{t-1}) + 0.97 \log(Y_{t-1}) - 1.05$. The standard errors of coefficients are given in parentheses.

$$\begin{bmatrix} \Delta \log(P_t) \\ \Delta \log(M_t) \\ \Delta \log(R_t) \\ \Delta \log(Y_t) \end{bmatrix} = \begin{bmatrix} \underset{(0.06)}{-0.27} \\ \underset{(0.14)}{0.26} \\ \underset{(0.36)}{-0.18} \\ \underset{(0.06)}{-0.04} \end{bmatrix} \beta X_{t-1} + \begin{bmatrix} \underset{(0.11)}{0.54} & \underset{(0.21)}{0.29} & \underset{(0.93)}{-0.35} & \underset{(0.10)}{0.10} \\ \underset{(0.06)}{-0.07} & \underset{(0.18)}{0.24} & \underset{(0.74)}{0.45} & \underset{(0.08)}{-0.08} \\ \underset{(0.02)}{-0.01} & \underset{(0.05)}{-0.06} & \underset{(0.20)}{0.15} & \underset{(0.07)}{-0.02} \\ \underset{(0.16)}{0.31} & \underset{(0.54)}{-0.54} & \underset{(1.39)}{0.93} & \underset{(0.16)}{0.06} \end{bmatrix}$$

$$\begin{bmatrix} \Delta \log(P_{t-1}) \\ \Delta \log(M_{t-1}) \\ \Delta \log(R_{t-1}) \\ \Delta \log(Y_{t-1}) \end{bmatrix} + \begin{bmatrix} \underset{(0.01)}{0.03} \\ \underset{(0.03)}{0.10} \\ \underset{(0.11)}{-0.06} \\ \underset{(0.01)}{-0.04} \end{bmatrix}$$

We are interested in finding out how the endogenous variables in VEC model respond to various shocks in the Pakistan economy. We quantify the dynamic effects of various shocks on the endogenous variables by calculating the variance decompositions and impulse responses. The ordering of the variables in calculating variance decompositions and impulse responses are *P*, *M*, *R* and *Y*. Results of variance decompositions are presented in Table 4. A number of interesting conclusions emerge from Table 4. First, the monetary shocks interpret about 26% and inflationary shocks interpret about 36% of the forecast error variance of the output growth. Thus, more than 60% of the variation in the forecast error of output growth is explained by monetary shocks and inflationary shocks combined. This result is consistent with KBC theory and MBC theory but inconsistent with RBC theory. It is interesting to note that results presented in Table 4 are also inconsistent with Sims empirical claim. According to Sims (1980, 1992), the role of money in output determination is very minor when interest rates are also included in the system. His studies show that interest rate play a leading role because the causal chain runs from interest rates to output to money to the price level.

TABLE 4

Variance Decomposition with Ordering
Δ log (*P*), Δ log (*M*), Δ log (*R*), Δ log (*Y*)

| Dependent Variables | Attributed to Innovations in | | | | | |
|---|---|---|---|---|---|---|
| | Years ahead | S E | Δ log (*P*) | Δ log (*M*) | Δ log (*R*) | Δ log (*Y*) |
| Δ log (*P*) | 1 | 0.031 | 100.0 | 0.0 | 0.0 | 0.0 |
| | 2 | 0.040 | 87.0 | 4.3 | 0.2 | 8.6 |
| | 3 | 0.047 | 80.2 | 9.0 | 0.1 | 10.7 |
| | 4 | 0.052 | 76.6 | 12.4 | 0.1 | 10.9 |
| | 5 | 0.057 | 74.3 | 14.7 | 0.1 | 10.8 |
| | 6 | 0.060 | 72.8 | 16.4 | 0.2 | 10.6 |
| | 7 | 0.063 | 71.7 | 17.6 | 0.2 | 10.5 |
| | 8 | 0.066 | 70.9 | 18.5 | 0.2 | 10.4 |
| | 9 | 0.068 | 70.3 | 19.2 | 0.2 | 10.3 |
| | 10 | 0.070 | 69.8 | 19.7 | 0.2 | 10.3 |
| | 11 | 0.072 | 69.4 | 20.2 | 0.2 | 10.2 |
| | 12 | 0.073 | 69.1 | 20.5 | 0.2 | 10.2 |
| | 13 | 0.074 | 68.9 | 20.8 | 0.2 | 10.1 |
| | 14 | 0.076 | 68.6 | 21.1 | 0.2 | 10.1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 15 | 0.077 | 68.5 | 21.3 | 0.2 | 10.1 |
| | 16 | 0.077 | 68.3 | 21.4 | 0.2 | 10.1 |
| | 17 | 0.078 | 68.2 | 21.6 | 0.2 | 10.0 |
| | 18 | 0.079 | 68.1 | 21.7 | 0.2 | 10.0 |
| | 19 | 0.079 | 68.0 | 21.8 | 0.2 | 10.0 |
| | 20 | 0.080 | 67.9 | 21.9 | 0.2 | 10.0 |
| Δ log (*M*) | 1 | 0.071 | 10.8 | 89.2 | 0.0 | 0.0 |
| | 2 | 0.089 | 17.9 | 80.4 | 1.2 | 0.5 |
| | 3 | 0.098 | 23.9 | 74.2 | 1.4 | 0.5 |
| | 4 | 0.105 | 28.3 | 69.6 | 1.3 | 0.8 |
| | 5 | 0.111 | 31.5 | 65.9 | 1.2 | 1.4 |
| | 6 | 0.116 | 33.8 | 63.1 | 1.1 | 1.9 |
| | 7 | 0.120 | 35.6 | 61.0 | 1.1 | 2.3 |
| | 8 | 0.123 | 37.1 | 59.2 | 1.0 | 2.7 |
| | 9 | 0.126 | 38.2 | 57.8 | 1.0 | 3.0 |
| | 10 | 0.129 | 39.1 | 56.7 | 1.0 | 3.2 |
| | 11 | 0.131 | 39.9 | 55.8 | 1.0 | 3.4 |
| | 12 | 0.133 | 40.5 | 55.0 | 0.9 | 3.6 |
| | 13 | 0.135 | 41.0 | 54.3 | 0.9 | 3.7 |
| | 14 | 0.136 | 41.5 | 53.8 | 0.9 | 3.8 |
| | 15 | 0.137 | 41.9 | 53.3 | 0.9 | 3.9 |
| | 16 | 0.139 | 42.2 | 52.9 | 0.9 | 4.0 |
| | 17 | 0.140 | 42.5 | 52.6 | 0.9 | 4.1 |
| | 18 | 0.141 | 42.7 | 52.3 | 0.9 | 4.2 |
| | 19 | 0.141 | 42.9 | 52.0 | 0.9 | 4.2 |
| | 20 | 0.142 | 43.1 | 51.8 | 0.9 | 4.3 |
| Δ log (*R*) | 1 | 0.256 | 14.3 | 26.0 | 59.8 | 0.0 |
| | 2 | 0.258 | 14.0 | 25.5 | 59.9 | 0.7 |
| | 3 | 0.259 | 13.9 | 25.6 | 59.8 | 0.7 |
| | 4 | 0.259 | 13.9 | 25.7 | 59.7 | 0.7 |
| | 5 | 0.259 | 13.9 | 25.7 | 59.7 | 0.7 |
| | 6 | 0.259 | 14.0 | 25.7 | 59.7 | 0.7 |
| | 7 | 0.259 | 14.0 | 25.7 | 59.7 | 0.7 |
| | 8 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 9 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 10 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 11 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 12 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 13 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 14 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 15 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 16 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 17 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 18 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 19 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| | 20 | 0.259 | 14.0 | 25.7 | 59.6 | 0.7 |
| $\Delta$ log (*Y*) | 1 | 0.032 | 0.8 | 15.7 | 2.9 | 80.7 |
| | 2 | 0.036 | 7.6 | 21.1 | 2.6 | 68.7 |
| | 3 | 0.038 | 13.9 | 22.8 | 2.4 | 60.8 |
| | 4 | 0.040 | 18.6 | 23.6 | 2.2 | 55.5 |
| | 5 | 0.042 | 22.1 | 24.1 | 2.0 | 51.7 |
| | 6 | 0.044 | 24.7 | 24.5 | 1.9 | 48.8 |
| | 7 | 0.045 | 26.8 | 24.8 | 1.8 | 46.6 |
| | 8 | 0.046 | 28.5 | 25.0 | 1.7 | 44.8 |
| | 9 | 0.047 | 29.8 | 25.2 | 1.7 | 43.3 |
| | 10 | 0.048 | 30.9 | 25.3 | 1.6 | 42.2 |
| | 11 | 0.049 | 31.8 | 25.5 | 1.6 | 41.2 |
| | 12 | 0.049 | 32.6 | 25.6 | 1.6 | 40.3 |
| | 13 | 0.050 | 33.2 | 25.6 | 1.5 | 39.6 |
| | 14 | 0.050 | 33.8 | 25.7 | 1.5 | 39.0 |
| | 15 | 0.051 | 34.2 | 25.8 | 1.5 | 38.5 |
| | 16 | 0.051 | 34.6 | 25.8 | 1.5 | 38.1 |
| | 17 | 0.052 | 35.0 | 25.9 | 1.4 | 37.7 |
| | 18 | 0.052 | 35.3 | 25.9 | 1.4 | 37.4 |
| | 19 | 0.052 | 35.6 | 26.0 | 1.4 | 37.1 |
| | 20 | 0.052 | 35.8 | 26.0 | 1.4 | 36.8 |

Notes: The number show the percentage of the forecast error variance of the dependent variable attributable to shocks to each of the variables of the system S.E. is the standard error using 100 draws from the Monte Carlo approach. A significant point estimate should be at least twice as large as its standard error.

Examination of Table 4 shows that interest rate shocks explain less than 3% of the forecast error variance of output growth. Thus, interest rate plays a minor role when money is included in the system.

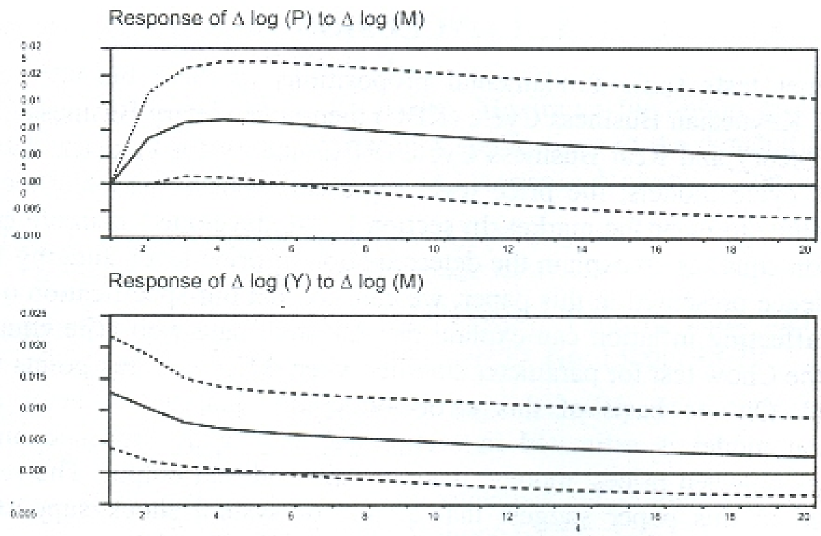
Second, examination of variance decomposition of money growth shows that almost half of the forecast error variance is explained by inflationary shocks and real output explains only about 4% of the forecast error variance of money growth. The results do not provide support to RBC theory, which claims fluctuations in real output are the major cause of fluctuations in money growth, or to MBC theory which claims that money supply is exogenously determined and is the cause of fluctuations in inflation and output.

Third, the variance decomposition for inflation shows that inflation is not only a monetary phenomenon. Forecast error variance of inflation explained by output shocks is almost half of that explained by the monetary shocks.

Having shown the dynamic effects of variance decompositions, we also look at the dynamic effects of monetary shocks on real output and prices by calculating the impulse responses based on the VEC model. Figure 3 displays two standard deviation band around the point estimates. The bold lines are point estimates. Impulse response functions at horizons 1-20 years have been computed. The ordering of the variables in computing response is *P*, *M*, *R* and *Y*.

FIGURE 3

Response to One SD Innovations 2±SE




According to MBC theory, the effects of monetary shocks will first show up for output over two to three quarters. Such effects tend to vanish quickly. The effects on prices come some twelve to eighteen months later and die out slowly. According to KBC theory, the effects of monetary shocks on real output does not die down quickly. Examination of Figure 3 shows that effects of monetary shocks on both output and prices die out slowly over a long time horizon. These results are consistent with a recent study done by Bernanke and Mihov (1998). Bernanke and Mihov estimate a structural vector auto-regressive model and present the impulse response function for real GDP in response to monetary shocks. Their impulse response function shows large impact of monetary shocks on real GDP even after 10 years.

Thus, the empirical evidence presented in this paper both from variance decompositions and impulse responses support the KBC theory for Pakistan data. Empirical evidence presented in this study also has some policy implications for monetary authorities. Examination of variance decomposition of output growth in Table 4 shows that forecast error-variance of output growth explained by change in interest rate shocks, monetary shocks and inflation shocks is 1.4%, 26%, 35.8% respectively. Thus, a clear choice for monetary authorities to attain a stable path for output growth is money growth rate targeting or inflation targeting as opposed to interest rate changes. In the short-run (1-5) years money growth rate targeting is better choice than inflation rate targeting. However, in the long-run (more than 5 years) inflation targeting is better choice than money growth targeting.

## V. CONCLUSION

This paper tests some fundamental propositions of 'three business cycle theories, Keynesian Business Cycle (KBC) theory, Monetary Business Cycle (MBC) theory and Real Business Cycle (RBC) theory for Pakistan data. In business cycle models, the price level represents a basic variable because prices adjust to clear the market. In section II, we developed a simple error-correction equation to explain the determination of price level. Judging from the evidence presented in this paper, we can say that our specification of the factors affecting inflation can explain the Pakistani data well. The equation passed the Chow test for parameter stability when different break points were specified. On the basis of this error-correction equation, a vector error correction model is estimated in section IV to provide evidence on the dynamics between prices, money, interest rates and real output. The results presented in this paper suggest that effects of system shock support the disequilibrium (Keynesian) business cycle theory. In the long-run, the inflation shocks explain relatively more variation in output growth than money growth or interest rate changes. Thus, the clear choice for monetary authorities to attain a stable path for output growth is by targeting money growth rate in the short-run and inflation rate in the long-run.

Banerjee, A., Dolado, J. J., Hendry, D. F. and Smith, G. W. (1986), Exploring equilibrium relationships in econometrics through static models: Some Monte Carlo evidence. *Oxford Bulletin of Economics and Statistics*, Volume 48, pp. 353-77.

Bernanke, B. S. and Blinder, A. S. (1992), The federal funds rate and the channels of monetary transmission. *American Economic Review*, Volume 82, pp. 901-21.

Bernanke, B. S. and Mihov, I. (1998), The liquidity effect and long-run neutrality. *NBER Working Paper* No. 6608.

Cook, D. (1999), The liquidity effect and money demand. *Journal of Monetary Economics*, Volume 43, pp. 377-90.

Engle, R. F. and Granger, C. W. (1987), Cointegration and error-correction representation, estimation and testing. *Econometrica*, Volume 66, pp. 251-76.

Fisher, S. (1997), Long-term contracts, rational expectations, and the optimal money supply rule. *Journal of Political Economy*, Volume 85, pp. 191-206.

Friedman, M. (1968), The role of monetary policy. *American Economic Review*, Volume 58, pp. 1-17.

Johansen, S. and Juselius, K. (1990), Maximum likelihood estimation and inferences on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, Volume 52, pp. 169-210.

King, R. G. and Plosser, C. I. (1984), Money, credit and prices in a real business cycle. *American Economic Review*, Volume 72, pp. 363-80.

Kydland, F. E. and Prescott, E. C. (1982), Time to build and aggregate fluctuations. *Econometrica*, Volume 50, No. 13, pp. 45-70.

Lucus, R. E. (1972), Expectations and neutrality of money. *Journal of Economic Theory*, Volume 4, pp. 103-124.

Lucus, R. E. (1973), International evidence on output-inflation tradeoffs. *American Economic Review*, Volume 63, pp. 326-334.

Phelps, E. (1969), The new microeconomics in inflation and employment theory. *American Economic Review*, Volume 59, pp. 147-160.

Sims, C. A. (1980), Comparison of interwar and postwar business cycles: Monetarism reconsidered. *American Economic Review*, Volume 70, pp. 250-7.

Sims, C. A. (1992), Interpreting the macroeconomics time series facts. *European Economic Review*, Volume 36, pp. 975-1011.

Taylor, J. (1980), Aggregate dynamics and staggered contracts. *Journal of Political Economy*, Volume 88, pp. 1-23.

Thoma, M. A. (1994), Subsample instability and asymmetries in money-income causality. *Journal of Econometrics*, Volume 64, pp. 279-306.