

Monetary Disequilibrium and Inflation: A Monetary Model of Inflation in Pakistan, 1963–82

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This paper develops and estimates a monetary model of inflation in Pakistan over the 1963–82 period. Both domestic and external factors are identified as the major determinants of inflation. Dynamic simulation results suggest that the model is able to track the fluctuations of endogenous variables and, most importantly, the inflation explosion during the 1970s is clearly predicted by the inflation equation.

I. INTRODUCTION

Inflation has been a major problem in most of the developing countries (including Pakistan) since the early 1970s and, because of its persistence over more than a decade, economists and policy-makers have particularly become highly concerned about the vulnerability of those countries to inflation. Inflationary experiences of the developing countries in the 1970s are generally explained in terms of world inflation and its transmission to the developing countries. In addition to the transmission of international inflation, expansionary monetary and fiscal policies (which are to some extent influenced by external inflationary pressure) are also expected to be responsible for a rapid rise in prices in most of the developing countries.

In this paper we will develop and estimate a simple monetary model of inflation in Pakistan over the 1963–1982 period.¹ The common practice of identifying the major determinants of inflation in the developing countries is to derive an inflation model from a money demand function in the tradition of the monetarist

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¹We have consistent data over the 1960–82 period. Three observations are, however, lost because of the transformations of some variables in logarithmic differential form and for having lagged variables in the estimating model. The actual estimation period is 1963–82.

school. Although monetary factors remain the major determinants of inflation in most of the developing countries, a simple monetarist model of inflation (developed in the context of a closed economy) generally comes under attack mainly for three reasons:

(1) Such a model fails to accommodate the recent outbreak of worldwide inflation – particularly in the developing countries. Furthermore, it does not show the transmission mechanism of world inflation into the domestic economy in a world of flexible and/or controlled exchange-rates system.

(2) The simplified monetarist model disregards the effects of money supply on real output which might arise through changes in the price level. Considering the existence of unutilized and underutilized resources in most of the developing countries, a short-run inflation model merits the inclusion of a feedback mechanism from a short-run supply function of output.

(3) The simplified monetarist model assumes that the money market is always in equilibrium, which is very unlikely in a developing country because of the non-existence of a well-developed financial market. The weak nature of the financial market results in an adjustment process which requires considerable time instead of instantaneous clearance as assumed in the traditional model like the Cagan model [5].

In order to overcome some of these shortcomings, we will specify our model by relaxing the assumption of instantaneous equilibrium in the money market. We will also allow for a feedback relationship between output and the rate of inflation. In order to show the mechanism of transmission of international inflation to the rate of domestic inflation, we will distinguish between traded and non-traded goods. We will also examine the influence of the changes in the terms of trade between traded and non-traded goods on the changes in the price level.

From a theoretical point of view, the model will be based on the monetary approach and its formulation in many ways will be similar to the Blejer model of inflation [4]. However, one basic distinction between the Blejer model and the present one will be that, whereas Blejer formulated his model in terms of a flow disequilibrium in the money market, the present model will be specified within the framework of a stock disequilibrium in the money market. The concept of stock disequilibrium in the money market is essentially similar to the concept used by Cagan [5] in his classic model of hyperinflation.

Including the introduction, this paper is organized in four sections. Section II specifies the model. Section III estimates the model and analyses the results. In order to test the goodness of fit, a dynamic simulation test is conducted and the results are also reported. Section IV draws conclusions. Data sources and definitions of the variables are reported in Appendix A.

II. SPECIFICATION OF THE MODEL

Specification of the Inflation Equation

We assume that the goods transacted in an open economy can be divided into traded and non-traded goods. The domestic price level (P_t) then can be defined as the weighted average of the prices of traded (PT_t) and non-traded goods (PNT_t). We write the relationship in logarithmic form as

$$\ln P_t = \alpha \ln PT_t + (1 - \alpha) \ln PNT_t \quad \dots \quad \dots \quad \dots \quad (1)$$

where α is the share of traded goods in total expenditure. As an approximation we will assume that α is a constant.²

We maintain the assumption of a small economy in the sense that the prices of traded goods are determined in the international market. From the purchasing power parity proposition it follows that

$$\ln PT_t = \ln PFE_t + \ln PW_t \quad \dots \quad \dots \quad \dots \quad \dots \quad (2)$$

where

PT_t = price of traded goods in domestic currency;

PFE_t = foreign-exchange rate; and

PW_t = price of traded goods in foreign currency.

We postulate that the price of non-traded goods in an open economy changes (i) in response to a disequilibrium in the money market and (ii) owing to variation in

²One referee enquired whether the share of traded goods remains constant during the period of our study. We have calculated the share of traded goods in total national expenditure for Pakistan over the 1960–82 period. The lower and upper limits of the share of traded goods are 0.23 and 0.28 for the 1960–69 period, 0.17 and 0.19 for the 1970–72 period and 0.27 and 0.32 for the 1973–82 period. We estimated the share of traded goods in total expenditure over the 1960–82 period on time trend (T). The estimated equation is

$$((EX + IM)/GNE) = 0.259 + 0.0019 T \\ (12.38) \quad (1.23)$$

where EX = Exports; IM = Imports; and $GNE = GDP - \text{Exports} + \text{Imports}$.

The estimated coefficient of time trend (T) is not significantly different from zero. Given the restriction that $\alpha = \alpha_t$ we will also estimate the inflation equation in order to examine whether the estimated results improve without this restriction.

the terms of trade between traded and non-traded goods. Then we can specify the following adjustment equation:

$$\ln PNT_t - \ln PNT_{t-1} = \lambda_1 (\ln (M/P)_{t-1} - \ln (M/P)_t^d) + \lambda_2 (\ln (PT_t/PNT_{t-1})) + U_t \quad \dots \quad (3)$$

In Equation (3), monetary disequilibrium is specified in discrete time framework.³ Such a specification implies that if actual real money balances at the beginning of a period ($\ln(M/P)_{t-1}$) differ from the money balances that individuals desire to hold at the end of the period ($\ln (M/P)_t^d$), then individuals would adjust their actual real balances either by disposing of or by building up actual (nominal) money balances. It also implies that any disequilibrium in the money market either increases or reduces private expenditure and subsequently changes the price of non-traded goods which would ultimately bring equilibrium in the money market. (For details, see Hossain [15]). λ_1 is the partial-adjustment coefficient and its value is expected to lie between zero and unity. The partial-adjustment equation suggests that only a proportion (λ_1) of the discrepancy between the desired and actual real money balances is eliminated within the period $t-1$ and t .

The second term (in the right-hand side of Equation (3)) shows that a rise in the price of traded goods in the current period increases the price of traded goods compared with the price of non-traded goods which prevailed at the last period. An increase in the relative price of traded goods subsequently increases the price of non-traded goods because there will be an increased demand for non-traded goods coupled with a reduction in the supply of non-traded goods (owing to the outflow of productive resources from the non-traded goods sectors). (See Aghevli and Sasanpour [1] for related arguments.) The disturbance term U_t allows for random influences in carrying out the adjustment process.

Take the first-order logarithmic differential of Equations (1) and (2) as follows:

$$\ln (P_t/P_{t-1}) = \alpha (\ln (PT_t/PT_{t-1})) + (1 - \alpha) \ln (PNT_t/PNT_{t-1}) \quad \dots \quad (4)$$

³ One referee suggested that instead of $(\ln (M/P)_{t-1} - \ln (M/P)_t^d)$, $(\ln (M/P)_t - \ln (M/P)_t^d)$ should be used in order to define disequilibrium in the money market so that in the simplified reduced-form equation $\ln (M/P)_t$ rather than $\ln (M/P)_{t-1}$ becomes the determinant of inflation. For a continuous model it is obvious that $(\ln (M/P)_t - \ln (M/P)_t^d)$ measures the disequilibrium in the money market, whereas in a discrete time framework it is the common practice to define disequilibrium as the difference between $\ln (M/P)_{t-1}$ and $\ln (M/P)_t^d$. We will, however, estimate our inflation equation using $\ln (M/P)_t$ and $\ln (M/P)_{t-1}$ alternatively and will check which variable performs better in explaining the rate of inflation in Pakistan. In order to test the comparative goodness of fit, we will use the simple likelihood criterion which in our case will be simply the comparison between the residual sums of squares.

$$\ln (PT_t/PT_{t-1}) = \ln (PFE_t/PFE_{t-1}) + \ln (PW_t/PW_{t-1}) \dots \dots (5)$$

Substitute Equations (3) and (5) into Equation (4), and after rearrangement we get

$$\begin{aligned} \ln (P_t/P_{t-1}) = & \alpha [(\ln (PFE_t/PFE_{t-1}) + \ln (PW_t/PW_{t-1})) \\ & + (1 - \alpha)\lambda_1 [\ln (M/P)_{t-1} - \ln (M/P)_t^d] \\ & + (1 - \alpha)\lambda_2 (\ln (PT_t/PNT_{t-1}) + (1 - \alpha) U_t \dots \dots (6) \end{aligned}$$

Having specified such an inflation equation by incorporating a monetary disequilibrium term, we must face the major problem of finding a suitable proxy for monetary disequilibrium when estimating the equation. In Lioi's study [21] the estimated residual of the money demand function has been used as a proxy for monetary disequilibrium. Lioi's technique, however, is not appropriate in our case. In a complete macromodel, such as Hossain's [16], the desired demand for real money balances enters as an endogenous variable and unless the coefficient of actual real money balances (in the inflation equation) is zero, the estimated residual cannot be used as a proxy for monetary disequilibrium.⁴ Lioi's strategy also raises major econometric problems. Leiderman [20] and Barro and Rush [2] point out that the equation to be estimated and the equation from which the residuals were derived must be estimated jointly if efficiency in estimation is to be obtained. Furthermore, Mishkin [25] found that it was not just a question of efficiency but also one of invalid inferences. Pagan [27] has thoroughly examined the major econometric problems arising from appearance of generated variables in a regression equation. He suggests that for consistent and efficient estimators to be obtained in such a regression, stringent conditions need to be imposed, but, according to him, it is unlikely that these conditions will be met in most studies. Considering these factors, we prefer not to adopt Lioi's technique. Instead, we will specify the desired demand for real money balances and will substitute this into Equation (6) so that the determinants of the desired demand for real money balances become the regressors in the inflation equation.

There is voluminous literature on the desired demand for real money balances in the developing countries. A thorough examination of the literature by Hossain [17] suggests that real income (measured or permanent) and the expected rate of inflation are the two important determinants of the desired demand for real money

⁴ I am grateful to Joceyln Horne who reminded me of this point.

balances. We specify the desired demand for real money balances in the following (semi-) logarithmic form⁵

$$\ln (M/P)_t^d = a_0 + a_1 \ln Y_t - a_2 p_t^e \quad \dots \quad \dots \quad \dots \quad \dots \quad (7)$$

where

Y_t = measured real income; and

p_t^e = expected rate of inflation.

We also postulate that in the developing countries, the expected rate of inflation can be approximated by a weighted average of past inflation rates so that we can write

$$p_t^e = \sum \theta_i p_{t-i}, i = 1, 2, 3, \dots, \infty \quad \dots \quad \dots \quad \dots \quad (8)$$

where θ_i represents the weight given to the i th period lagged rate of inflation. It is important to note that the contemporaneous inflation rate is put to zero. This is because in the developing countries the system of collecting and disseminating statistical data is inefficient and slow so that the economic agents are more likely to form their future expectations for this variable on the basis of past inflation rates alone. (See Darrat [6] for details.)

Substitute Equation (8) into Equation (7) and then substitute the resulting money demand equation into Equation (6). After rearrangement we get the following equation.

$$\begin{aligned} \ln (P_t/P_{t-1}) = & -(1-\alpha)\lambda_1 a_0 + \alpha [(\ln (PFE_t/PFE_{t-1})) \\ & + \ln (PW_t/PW_{t-1})] + (1-\alpha)\lambda_1 \ln (M/P)_{t-1} \\ & - (1-\alpha)\lambda_1 a_1 \ln Y_t + (1-\alpha)\lambda_1 a_2 \sum \theta_i p_{t-i} \\ & + (1-\alpha)\lambda_2 (\ln (PT_t/PNT_{t-1})) + (1-\alpha) U_t \quad \dots \quad (9) \end{aligned}$$

⁵ Such a specification has been suggested by Khan [18] in developing countries where rates of inflation for many years are found to be negative. The author also found such a specification suitable for Bangladesh. One can, however, use $\ln p_t^e$ if inflation rates over the study period are found to be positive. Frenkel [8] has examined both semi-logarithmic and double logarithmic forms of the money demand function for German hyperinflation and concluded that there was no clear preference for one to the other. For the years 1962-63 and 1967-68, inflation rates in Pakistan were found to be negative, which forced us to use p^e rather than $\ln p^e$ in our specification.

Equation (9) needs further simplification in order to make it suitable for estimation using data for Pakistan. During the period of our study, exchange rates in Pakistan have been institutionally determined and remained at the same level over several years at a stage. From 1960 to 1972, the official exchange rate was fixed at Rs 4.76 (per US dollar), while from 1973 to 1981 the exchange rate was changed to Rs 9.90 per US dollar. Lipschitz [22] finds that the extent of official intervention in the foreign-exchange market depends upon the origin of short-term shocks to the economy, and also that policy decisions regarding the exchange rates of the developing countries are taken following some sort of reaction function that is aimed at maximizing a government utility function. Ujiie [31] elaborates different forms of reaction functions of the monetary authority. A simple specification of such a reaction function is related to the variation in the terms of trade between traded and non-traded goods:⁶

$$\ln PFE_t - \ln PFE_{t-1} = \beta (\ln PT_t - \ln PNT_{t-1}) \dots \dots \dots (10)$$

The parameter β takes a value which lies between zero and unity.

In Equation (10) it is postulated that the monetary authority tries to maintain stable terms of trade between traded and non-traded goods through a change in the exchange rate under a controlled exchange-rate system. The above equation shows that a change in the price of traded goods in the current period changes the relative price of traded goods compared with the price of non-traded goods which prevailed at the last period. And any change in the terms of trade between traded and non-traded goods is expected to affect the production structure and subsequently the balance of payments of the economy. In order to maintain a stable balance of payments of the economy, the monetary authority is then expected to change the exchange rate to bring stability to the foreign sector.

Substitute Equation (10) into Equation (9), and after rearrangement we get the following estimating equation:⁷

$$\begin{aligned} \ln (P_t/P_{t-1}) = & -(1 - \alpha)\lambda_1 a_0 + \alpha \ln (PW_t/PW_{t-1}) \\ & + (1 - \alpha)\lambda_1 \ln (M/P)_{t-1} - (1 - \alpha)\lambda_1 a_1 \ln Y_t \\ & + (1 - \alpha)\lambda_1 a_2 \Sigma \theta ip_{t-1} + (\alpha\beta + (1 - \alpha)\lambda_2) (\ln (PT_t/PNT_{t-1})) \\ & + (1 - \alpha) U_t \dots \dots \dots (11) \end{aligned}$$

⁶I am grateful to an anonymous referee for suggesting to me such a reaction function.

⁷The equation is exactly identified with the restriction that the adjustment coefficient of the reaction function is unity.

Short-run Aggregate Supply Function of Output

The real income variable, which enters into the money demand function and acts as a deterring factor of price inflation in Equation (11), is also expected to be affected by changes in the price level.⁸ This gives rise to the problem of simultaneity in the inflation equation. To complete the model, and particularly in order to account for the feedback of inflation on real output, it is necessary to specify an aggregate supply function of output, preferably in the monetary framework. In the developing countries in particular, the existence of unutilized and underutilized resources merits the inclusion of a short-run supply function of output in a short-run inflation model. We specify the following supply function in the form of a single reduced-form equation.

$$\ln Y_t = \ln Y_t^n + \gamma (\ln P_t - \ln P_t^e) \quad \dots \quad \dots \quad \dots \quad (12)$$

where Y_t represents the measured aggregate real output and Y_t^n measures the natural (or permanent) real output which is considered to be determined by the long-run trends in capital, labour force and technology. The cyclical component of aggregate output is expected to be a function of the ratio of actual to expected price level. If the actual price level exceeds the expected price level, entrepreneurs are assumed to interpret the difference as a real increase in demand for their products. In the short-run, in order to meet the increased demand they are expected to raise the rate of capacity utilization of the existing capital stock and invest more to increase the capacity for production [9]. In Equation (12), P_t and P_t^e represent the current price level and the price level expected by workers, given the information available at time t .

The specified supply function is popularly called the Lucas supply function (see [23]). Gordon [11], however, prefers to refer to it as the Friedman supply function.

Nugent and Gleznos [26] modified such an aggregate supply function by incorporating the real price of foreign exchange as an independent factor of production. They argue that the real price of foreign exchange (*RPFE*) measures the

⁸ One referee enquired whether the relationship between inflation and real economic growth is positive or negative. The rate of inflation does not bear any conclusive relationship with the rate of economic growth. Thirlwall and Barton [28], taking fifty-one countries over the 1958–67 period, found no significant relationship between inflation and economic growth over the whole sample. Tun Wai [30] in a study of thirty-one developing countries, found a positive relationship between inflation and economic growth up to a critical inflation rate after which growth has to decline. On the other hand, Wallich [32], in a cross-section of forty-three countries over the 1956–65 period, found a negative relationship between inflation and economic growth. The author used a modified index of price instability defined as the deviation of inflation (in absolute terms) from unit trend rate of inflation and found a significant negative relationship between price instability and real economic growth for eight developing ESCAP countries (including Pakistan). (See Hossain, [14], for details.)

relative profitability of exports and, if unemployed and underemployed domestic resources can be substituted for scarce foreign factors, exchange-rate-induced exports can stimulate aggregate output and income. In Pakistan, although the nominal exchange rate has remained constant for lengthy periods, (because of price movements) the real price of foreign exchange has nonetheless been fluctuating over time and, as a result, we will be able to examine the Nugent-Gleznos hypothesis for Pakistan. We, therefore, extend the aggregate supply equation, Equation (12), by incorporating the logarithm of the real price of foreign exchange as an extra factor of production. Then our supply equation becomes

$$\ln Y_t = \ln Y_t^n + \gamma (\ln P_t - \ln P_t^e) + b_1 \ln RPFE_t \quad \dots \quad (13)$$

We assume that the normal output (Y_t^n) or, in Friedman's sense, the anticipated or permanent output can be expressed as the weighted average of past measured outputs such as

$$Y_t^n = \sum c_i Y_{t-i}, i = 1, 2, 3, \dots, \infty \quad \dots \quad (14)$$

where c_i is the weight imposed on the i th period lagged real output.

Following Hanson [12, p. 976], we hypothesize that workers forecast next period's price level by taking (the log of) past prices as given and adding their prediction of inflation so that

$$\begin{aligned} \ln P_t^e &= \ln P_{t-1} + d/dt (\ln P^e) \\ &= \ln P_{t-1} + p_t^e \quad \dots \quad \dots \quad \dots \quad \dots \quad (15) \end{aligned}$$

$$\text{where } p_t^e = d/dt (\ln P^e)$$

Similarly we also define

$$\begin{aligned} \ln P_t &= \ln P_{t-1} + d/dt (\ln P) \\ &= \ln P_{t-1} + p_t \quad \dots \quad \dots \quad \dots \quad \dots \quad (16) \end{aligned}$$

Substitute Equations (15), (16) and (14) into Equation (13), and after rearrangement we get

$$\ln Y_t = \sum c_i Y_{t-i} + \gamma p_t - \gamma p_t^e + b_1 \ln RPFE_t \quad \dots \quad (17)$$

Now, if we substitute Equation (8) into Equation (17), we will get the following estimating equation (written in the form of an econometric equation):

$$\ln Y_t = c_0 + \sum c_i Y_{t-i} + \gamma p_t - \gamma \sum \theta_i p_{t-i} + b_1 \ln RPFE_t + V_t \quad \dots \quad (18)$$

where c_0 is an intercept and V_t is a disturbance term.

Equations (11) and (18) represent the simultaneous-equation system where $\ln (P_t/P_{t-1})$ and $\ln Y_t$ are the endogenous variables. In the following section, these equations will be used for estimation.

III. ESTIMATION AND RESULTS

Estimation Techniques and Problems

The model has been estimated using annual data for Pakistan over the 1963–82 period. An instrumental-variables approach has been used for estimation. In the selection of the estimator, we made some compromises. We considered mainly two factors: (i) the possibility of a specification error, and (ii) the quality of data. As far as the specification of the model is concerned, it is very difficult to rule out the possibility of any specification error so long as the model explains only a specific aspect of the economy and the model is expected to belong to a larger macro-economic model. Turning to the quality of the data, the data used for the estimation of the model have been taken from both national and international sources. We are especially concerned about the data for the 1960–71 period when Bangladesh was a part of Pakistan. This is because, although we have used data mainly from a standard secondary source (*International Financial Statistics*), it is possible that observations for the 1960–71 period have been (guess-) estimated from data for Pakistan and Bangladesh taken together. As a result, there may be some inconsistency in the data series for several variables.

Considering these factors, we have not used the full-information maximum-likelihood estimator (*FIML*) which generally provides the most desirable properties when the model is correctly specified and the variables are correctly measured. In fact, *FIML* is extremely sensitive to both specification and measurement errors. An ordinary least-squares estimator, on the other hand, would be expected to produce inconsistent estimates because of the simultaneous nature of our model. We have, therefore, used the instrumental-variables approach, as it performs best among the limited information estimators. In particular, it is less affected by the specification error. Preliminary estimation revealed autocorrelation which was corrected, using iterative procedure suggested by Fair [7]. The major problem of using the instrumental-variables approach was to find an appropriate instrument for real income in the inflation equation. The necessary condition for selecting an instrument for real

income is that the instrument should be contemporaneously uncorrelated with the disturbance term, while highly correlated with the real income variable. In the absence of any autocorrelation problem, lagged real income can be used as an instrument, given that $E(\ln Y_{t-1}, U_t) = 0$ and a high correlation exists between $\ln Y_t$ and $\ln Y_{t-1}$. Since our inflation equation shows that the error term is autocorrelated, we did not use $\ln Y_{t-1}$ as the instrument. Instead, we constructed an instrument (IY_t) by adding real exports to real fixed investment. The estimated correlation coefficient between $\ln Y_t$ and $\ln IY_t$ has been found to be 0.89. Preliminary estimation results also suggest that the lagged inflation variables of more than one period are not statistically significant and thus do not reduce the sum of squared residuals. Since we have only 20 observations, in our preferred equation we have used one period lagged rate of inflation as the proxy for the expected rate of inflation. Our decision for considering only one lag term may seem inappropriate, at least from a theoretical point of view. We have, however, been encouraged by recent empirical findings on this issue for other developing countries. Bhalla [3] found that one period lag rate of inflation can better be used as a proxy for the expected rate of inflation. Toyoda [29, p. 273] found that "the time span for the formation of price expectations is very short. $p_t^e = p_{t-1}$ gives the best statistical result." Mallineax [24, p. 152] found that in the formation of price expectations only two lag terms in past inflation are statistically significant and "additional terms in past inflation were never significant". In the aggregate supply equation, lagged output of more than one period has also not been found to be statistically significant. We, therefore, preferred to report the equation estimated with a one period lag.

We estimated the inflation equation in two forms. (1) We put a restriction that the coefficient on $\ln (PW_t/PW_{t-1})$ is equal to α_t (which we have calculated as the share of traded goods in total expenditure). Such *a priori* information about the coefficient of any explanatory variable has some econometric advantages in reducing the variance of the coefficient [19, pp. 432-433]. (2) We also estimated the equation without imposing any restriction on the coefficient of $\ln (PW_t/PW_{t-1})$. One reason for estimating the inflation equation in two forms is that it enables us to check whether the restricted and unrestricted versions give similar results. If the results for both versions are found to be similar, then our proxy variable for the price of traded goods in the international market can be considered to be an appropriate one.

Estimation Results

The estimated results are presented below. The figures in parentheses below the coefficients are *t*-ratios. *SER* and *SSR* represent the standard error of regression and the sum of the squared residuals respectively. *L* and *LM* are, respectively, the value of maximized likelihood function and the Lagrangian multiplier statistic about

the normality of residuals. ρ stands for autocorrelation coefficient. The statistic R^2 is not very meaningful as a test of explanatory power when the instrumental-variables approach is used for estimation. This is because the distribution of this statistic is not bounded between zero and unity; instead its value lies between ∞ and unity. It is, therefore, not reported. Simulation results, however, may be used to provide some evidence about the goodness of fit of the model. We, therefore, conducted a dynamic simulation test of the model. The regression of actual values on predicted values yields a coefficient whose value is 0.99 in the inflation equation and 0.90 in the real output equation. These figures are really very high.⁹

Estimates of Inflation Equation with Restriction

$$\begin{aligned} \ln(P_t/P_{t-1}) - \alpha_t (\ln(PW_t/PW_{t-1})) = & 0.142 - 0.185(1 - \alpha_t) \ln Y_t \\ & (0.962) \quad (3.45) \\ & + 0.223(1 - \alpha_t) \ln(M/P)_{t-1} \\ & (3.76) \\ & + 0.072(1 - \alpha_t) \ln(PT_t/PNT_{t-1}) \\ & (2.21) \\ & + 0.778(1 - \alpha_t) \ln(P_{t-1}/P_{t-2}) \\ & (6.64) \end{aligned}$$

$$\rho = -0.568, SSR = 0.015, SER = 0.029, L = 45.27, LM = 0.714, N = 20$$

CORRELOGRAM

Coeff.	-0.0637	-0.2910	-0.2446	0.2156	-0.2005	0.0985	-0.0364
t-stat.	-0.2847	-1.3016	-1.0937	0.9642	-0.8966	0.4406	-0.1626

Estimates of Inflation Equation without Restriction

$$\begin{aligned} \text{(i) } \ln(P_t/P_{t-1}) = & 0.080 - 0.234 \ln Y_t + 0.287 \ln(PW_t/PW_{t-1}) \\ & (0.50) \quad (2.85) \quad (3.24) \\ & + 0.350 \ln(M/P)_t + 0.811 \ln(P_{t-1}/P_{t-2}) \\ & (3.57) \quad (5.97) \\ & + 0.220 \ln(PT_t/PNT_{t-1}) \\ & (4.28) \end{aligned}$$

⁹ Although Goldfeld [10] considers dynamic simulation a stringent test of goodness of fit (and indeed a more relevant test from a forecasting point of view), such tests are sometimes undermined because of the fact that they create a dichotomy between the dependent and the explanatory variables during simulation. During simulation, usually the dependent and the lagged dependent variables are generated in the system, while the other explanatory variables take their actual values.

$$SSR = 0.014, SER = 0.0318, L = 43.760, LM = 0.883, \rho = -0.755$$

CORRELOGRAM

$$\begin{array}{l} \text{Coeff.} \quad -0.192 \quad -0.409 \quad 0.179 \quad 0.341 \quad -0.508 \quad 0.018 \quad 0.230 \quad -0.032 \\ t\text{-stat.} \quad -0.859 \quad -1.830 \quad 0.801 \quad 1.525 \quad -2.272 \quad 0.080 \quad 1.003 \quad -0.144 \end{array}$$

$$\begin{aligned} \text{(ii) } \ln(P_t/P_{t-1}) = & -0.066 - 0.118 \ln Y_t + 0.258 \ln(PW_t/PW_{t-1}) \\ & (0.47) \quad (2.58) \quad (3.20) \\ & + 0.193 \ln(M/P)_{t-1} + 0.566 \ln(P_{t-1}/P_{t-2}) \\ & (4.21) \quad (6.86) \\ & + 0.111 \ln(PT_t/PNT_{t-1}) \\ & (3.99) \end{aligned}$$

$$SSR = 0.009, SER = 0.0257, L = 48.109, LM = 0.701, \rho = -0.66$$

CORRELOGRAM

$$\begin{array}{l} \text{Coeff.} \quad -0.017 \quad -0.193 \quad -0.104 \quad 0.116 \quad -0.253 \quad 0.110 \quad -0.030 \quad -0.156 \\ t\text{-stat.} \quad -0.076 \quad -0.861 \quad -0.731 \quad 0.517 \quad -1.134 \quad 0.495 \quad -0.130 \quad -0.700 \end{array}$$

$$\begin{aligned} \text{Instruments} = & C, \ln(IY)_t, \ln(P_{t-1}/P_{t-2}), \ln(P_{t-2}/P_{t-3}), \\ & \ln(M/P)_{t-1}, \ln(PW_t/PW_{t-1}), \ln(RPFE)_t, \ln(PT_{t-1}/PNT_{t-2}) \end{aligned}$$

Estimates of Aggregate Supply Equation of Output

$$\begin{aligned} \ln Y_t = & -0.075 + 0.995 \ln Y_{t-1} + 0.049 \ln(P_t/P_{t-1}) \\ & (0.32) \quad (12.33) \quad (0.29) \\ & + 0.003 \ln(P_{t-1}/P_{t-2}) + 0.305 \ln(RPFE)_t \\ & (0.92) \quad (0.62) \end{aligned}$$

$$SSR = 0.021, SER = 0.0374, L = 40.193, \rho = -0.121$$

CORRELOGRAM

$$\begin{array}{l} \text{Coeff.} \quad -0.007 \quad -0.059 \quad 0.120 \quad -0.087 \quad -0.083 \quad -0.213 \quad -0.133 \quad -0.108 \\ t\text{-stat.} \quad -0.306 \quad -0.263 \quad 0.245 \quad -0.537 \quad -0.388 \quad -0.375 \quad -0.595 \quad -0.485 \end{array}$$

$$\begin{aligned} \text{Instruments} = & C, \ln(P_{t-1}/P_{t-2}), \ln(P_{t-2}/P_{t-3}), \ln(M/P)_{t-1}, \\ & \ln(PW_t/PW_{t-1}), \ln(RPFE)_t, \ln(PT_{t-1}/PNT_{t-2}) \end{aligned}$$

We have mentioned above that we need to test whether $(\ln(M/P)_t - \ln(M/P)_t^d)$ or $(\ln(M/P)_{t-1} - \ln(M/P)_t^d)$ measures disequilibrium in the money market in a

better way when discrete data are used for estimation. According to our specified inflation equation, the problem can be simplified by testing the following (unrestricted) alternative reduced-form inflation equations. We consider them as null and alternative hypotheses. d_i and e_i are the reduced-form coefficients.

$$H_0: \ln(P_t/P_{t-1}) = d_0 + d_1 \ln Y_t + d_2 \ln(PW_t/PW_{t-1}) \\ + d_3 \ln(M/P)_t + d_4 p_{t-1} + d_5 \ln(PT_t/PNT_{t-1}) + U_t$$

$$H_a: \ln(P_t/P_{t-1}) = e_0 + e_1 \ln Y_t + e_2 \ln(PW_t/PW_{t-1}) \\ + e_3 \ln(M/P)_{t-1} + e_4 p_{t-1} + e_5 \ln(PT_t/PNT_{t-1}) + V_t$$

Since these two hypotheses are non-nested, we cannot conduct the likelihood ratio test (by defining a composite equation where the hypothesis under test will be embedded within the composite equation) in a straightforward manner. Instead, we can discriminate between the hypotheses by comparing the maximized values of their respective likelihood functions. Since the correlograms of our estimating equations suggest that the corrected error term is normally distributed in each equation, a comparison of the values of maximized likelihood functions is in another way a comparison between the residual sums of squares [13]. The sum of squared residuals in our estimated equation having $\ln(M/P)_{t-1}$ is much lower than the sum of squared residuals with $\ln(M/P)_t$, which is also clearly reflected in the maximized values of likelihood functions of the estimating equations reported above. Furthermore, *LM*, *SER* and correlogram statistics suggest that the inflation equation having $\ln(M/P)_{t-1}$ performs better than the inflation equation having $\ln(M/P)_t$ variable. It thus appears that $(\ln(M/P)_{t-1} - \ln(M/P)_t)$ measures monetary disequilibrium in a better way for discrete data in Pakistan and we will also interpret our results accordingly.

Analysis of the Results

The estimated results of the inflation equation (both restricted and unrestricted forms) show that all the coefficients are consistent with *a priori* expectations and are statistically significant at the 1-percent level. Since the results of both the restricted and unrestricted forms of the inflation equation are not significantly different in terms of the signs and magnitudes of its coefficients, we will interpret the results of the unrestricted inflation equation which is intuitively easier to explain. A one-percentage-point increase in the international trade price index contributes a 0.29-percentage-point increase in the rate of domestic inflation. The international trade price index is the weighted average of the import and export price indexes of industrialized countries, where the proportions of the exports and imports to the

total trade of Pakistan have been used as weights. This variable has been used because we have mentioned in the text that international inflation influences the rate of domestic inflation mainly through international trade and the prices of traded goods are determined in the international market. The coefficient of real income is significantly different from zero with a negative sign. The estimated coefficient shows that a one-unit increase in real income (output) reduces the rate of inflation by 0.12 percentage point. The coefficient of the lagged rate of inflation bears a positive sign and is statistically highly significant. The estimated coefficient is consistent with the hypothesis that the expected rate of inflation is the most appropriate proxy for the opportunity cost of holding money and the expected rate of inflation can be approximated by a very recent lagged rate of inflation. The coefficient of lagged real money supply is significantly different from zero. This is consistent with the hypothesis that if real money supply at the beginning of a period exceeds the desired real money balances at the end of the period, then individuals would dispose of the actual nominal money balances by increasing their expenditure level which, in turn, ultimately increases the price level and subsequently the money market returns to the equilibrium level. The coefficient of the terms of trade between traded and non-traded goods is significantly different from zero, which implies that an increase in the relative price of traded goods (i.e. the price of traded goods in current year relative to the price of non-traded goods prevailing at the beginning of the last period) increases the rate of inflation. Dynamic simulation error structures for inflation and output variables are not presented here because of the shortage of space but may be available from the author upon request. The results suggest a reasonably good fit of the model and, importantly, the inflation equation has been able to track the inflation explosion during the 1970s. A comparison of the actual data series with the simulated series for each endogenous variable provides a useful test of the validity of the model. Actual and simulated values of rho-transformed inflation and real output variables are presented in Figs. 1 and 2.

Root-Mean-Squares (*RMS*) simulation error is one of the quantitative measures of how closely individual variables track their corresponding data series. It is relatively a better measure (in evaluating a multi-equation model) than the mean simulation error. This is because the mean simulation error is biased towards zero if large positive errors cancel out large negative errors.

In theory, the Theil inequality coefficient is expected to lie between zero and unity. When the simulated values perfectly coincide with the actual values, the inequality coefficient becomes zero, and the inequality coefficient becomes unity when the simulated values are totally different from the actual values. In our simulated model, Theil's inequality coefficient is very low for both inflation and output variables during the 1963–82 and 1971–82 periods. In an ideal situation, Theil's inequality coefficient should also be proportionally distributed as (a) fraction of

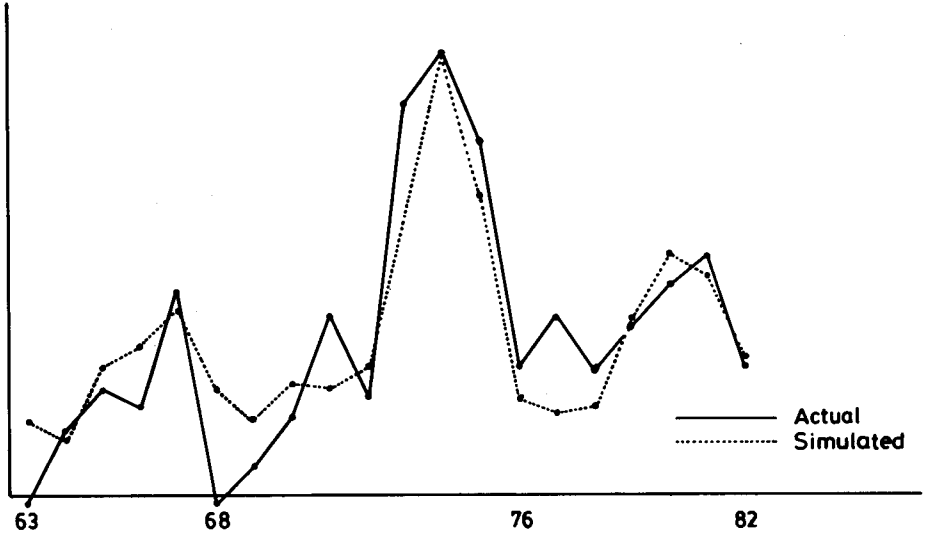


Figure 1. Actual and Simulated values of rho-transformed inflation variable over the period 1963–82.

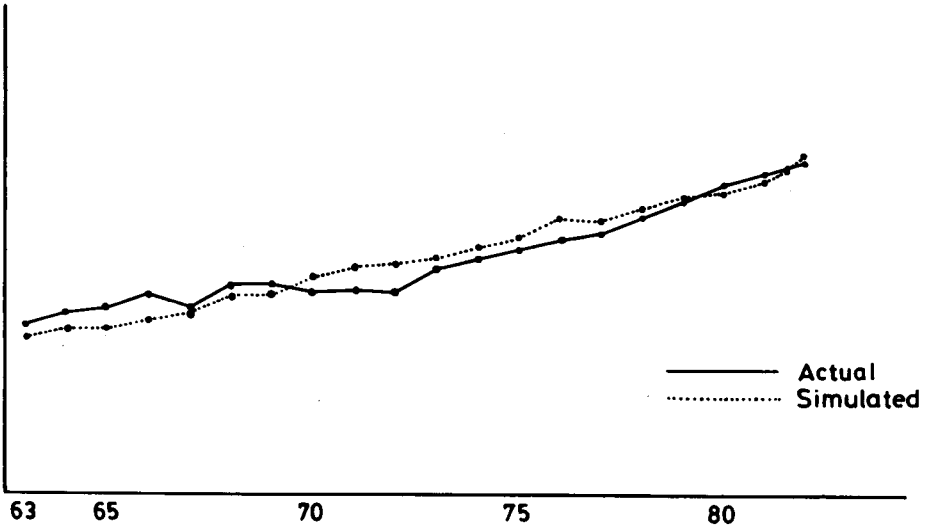


Figure 2. Actual and Simulated values of the rho-transformed real output variable over the period 1963–82.

error due to bias = 0; (b) fraction of error due to variation = 0; and (c) fraction of error due to co-variation = 1. In other words, (in an ideal situation) the fraction of error due to the difference of regression coefficient from unity should be zero and the fraction of error due to residual variance should be unity. The simulation error structure for the inflation and output equations satisfies the above requirements in a convincing way.

Another important measure of simulation fit is the extent to which the model simulates turning points in the historical data series. The ability of a model to reproduce turning points or direction of actual data is an important criterion of model simulation. The model which can track the turning points of actual data is better than the model which cannot. As far as our model is concerned, it is very important to note that the inflation equation in particular is quite successful in tracking the inflation explosion of Pakistan in the 1970s. The variability of inflation in the latter part of the 1970s is also correctly predicted.

The performance of a model is also tested by simulating the model for different sample periods. It is expected that if the model truly explains the observed data, then from a theoretical point of view it should not matter very much for what period the simulation is conducted. We conducted an additional simulation test for the 1971–82 period. The simulation error structure for this period, when compared with the simulation results for the 1963–82 period, does not show any significant difference in the model's performance.

IV. SUMMARY

This paper developed and estimated a simple monetary model of inflation in Pakistan over the 1963–82 period. The model was developed on the basis of an assumption that any disequilibrium in the real money market adjusts itself through changes in the price level but not instantaneously. In order to accommodate the recent outbreak of world-wide inflation and its influence to the generation and acceleration of inflation in most of the developing countries, the naive monetary model has been adjusted so as to make it more suitable for an open economy where prices of traded goods (determined in the international market) are expected to affect the domestic price level through direct and indirect channels. To complete the model and, particularly, to account for the feedback of inflation on real output, an aggregate supply function has also been specified in the form of a single reduced-form equation suggested by Lucas. An instrumental-variables approach has been used to estimate the model. Changes in the prices of traded goods in the international market (approximated by a weighted average of export and import price indexes derived from prices in US dollars, of industrialized countries, where the weights are the proportions of imports and exports to total trade of Pakistan), real income, real money supply, the expected rate of inflation (approximated by one

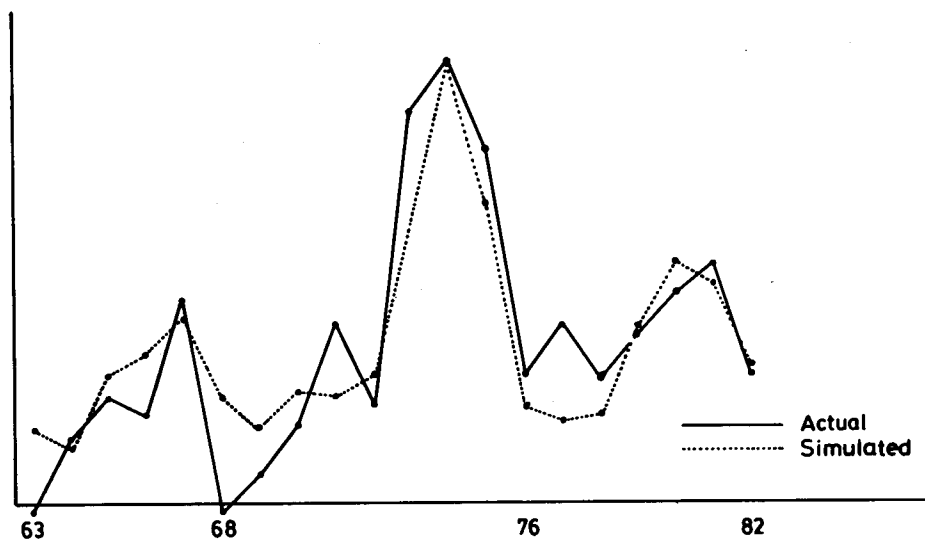


Figure 1. Actual and Simulated values of rho-transformed inflation variable over the period 1963–82.

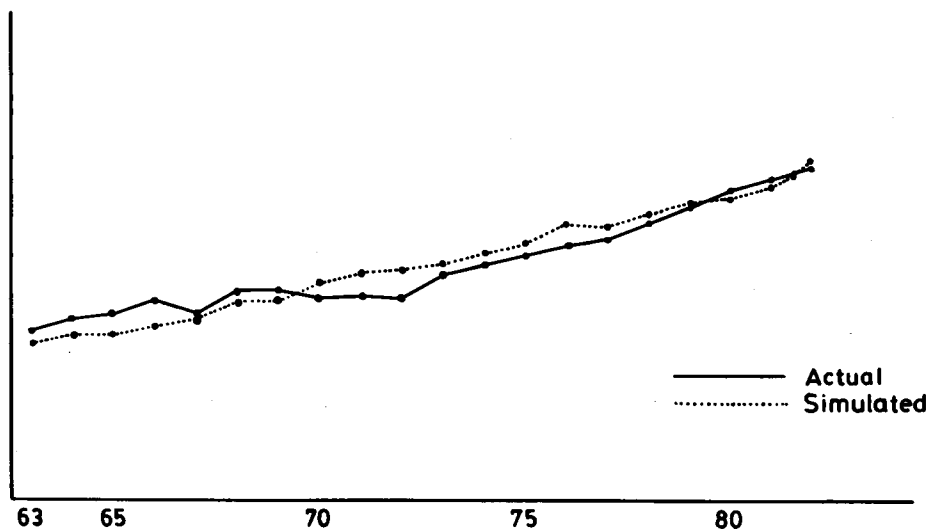


Figure 2. Actual and Simulated values of the rho-transformed real output variable over the period 1963–82.

error due to bias = 0; (b) fraction of error due to variation = 0; and (c) fraction of error due to co-variation = 1. In other words, (in an ideal situation) the fraction of error due to the difference of regression coefficient from unity should be zero and the fraction of error due to residual variance should be unity. The simulation error structure for the inflation and output equations satisfies the above requirements in a convincing way.

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period lagged rate of inflation), and changes in terms of trade between traded and non-traded goods have been found to be the major determinants of inflation in Pakistan. The aggregate level of output shows a steady increase over time with little fluctuation. Such fluctuations as there were are expected to be explained by the difference between actual and expected rates of inflation but these variables have not proven to be significant in our study. Contrary to the findings of Nugent and Glezanos, the real price of foreign exchange has been found to be insignificant in the aggregate supply function. In order to test the goodness of fit, we conducted a dynamic simulation test within the sample period, 1963–1982. The simulation results suggest that the model is able to track the fluctuations of endogenous variables, and, most importantly, the inflation explosion during the 1970s has been clearly predicted by the inflation equation. The simulation error structure suggests a reasonably good fit of the model.

Appendix A

Data Sources

- (A) *International Financial Statistics Yearbook*, 1980, 1982 and several other monthly issues.
- (B) *Pakistan Economic Survey, 1969-70* and several other issues.

Definition of Variables in the Regression Equations

- P_t = Consumer Price Index (*Source: A*);
- M_t = Narrow Money (Currency plus Demand Deposits) (*Source: A*);
- Y_t = GDP at constant prices (*Source: A*);
- PW_t = Weighted average of import and export unit values of industrialized countries. The weights are the proportions of exports and imports to total trade of Pakistan. Basic data used to calculate this weighted index have been taken from source A;
- $RPFE_t$ = Exchange rate of Pakistani Rupees per US Dollar deflated by Consumer Price Index (*Source: A*);
- PT_t = Weighted average of import and export unit values of Pakistan, where the weights are the proportions of imports and exports to total trade of Pakistan. Basic data for imports and exports are taken from source A, while import and export unit values are taken from sources A and B. In order to derive a consistent series, base year has been changed for both import and export unit value indexes over the 1960–70 period.
- PNT_t = $(NTGcu/NTGco) * 100$, where $NTGcu$ and $NTGco$ are non-traded goods, respectively, at current and constant prices. Non-traded goods at current/constant prices have been calculated by subtracting exports from GDP at current/constant prices. Real exports have been defined as current exports deflated by export unit values.

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