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Endogeneity of Monetary Policy Reaction Function: An Experience from Pakistan's Economy*

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1. INTRODUCTION

Monetary policy, in general, refers to those steps taken by the Central Bank to achieve such broader objectives of the economy as growth, employment, external balance and price stability through changes in the money supply, interest rates and credit policies. The money supply thus created by the Central Bank should be in response to the changes in key macroeconomic target variables such as GNP, balance of payments, inflation, internal debt and unemployment. Indeed, a properly estimated monetary policy reaction function can provide useful information regarding such matters as to whether the Central Bank, in fact, has been systematically accommodating to the changes in the target variables. The reaction function can also provide insight into the question as to what should be the relevant indicators of the monetary policy. In addition, as argued by Havrilesky (1967), it may also play a crucial role in the formulation of long-term monetary policy strategy.

The other important consideration in the development of a monetary policy reaction function pertains to the endogeneity of the monetary policy. As pointed out by Goldfeld and Blinder (1972), if a policy variable responds to the lagged (or expected) target values, then considering such a policy variable as exogenous would not only introduce the problem of misspecification but will also produce serious biases in the parameters estimated from those models. In particular, if the monetary policy variable happens to be strongly influenced by target variables, then the standard result of the relative effectiveness of the monetary policy *vis-a-vis* fiscal policy can be questionable on the grounds of reverse causation problem.

In recent years, although several large and small macroeconometric models

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have been developed[1] for Pakistan, most of these models in one way or another, treated the monetary policy reaction function as exogenous.[2] In fact, some of the recent studies on the relative effectiveness of monetary and fiscal policies [e.g., Masood and Ahmad (1980); Hussain (1982); Saqib and Yasmin (1987)] have arbitrarily assumed the exogeneity of the monetary policy without conducting an appropriate exogeneity test of such policy variables.

This study is an attempt to empirically estimate such a monetary policy reaction function for Pakistan using an annual data set over the period 1961 to 1986. Estimation of such a monetary policy reaction function would enable us to answer and address the issues raised earlier in the paper.

It is also important to point out that the reaction function developed in this paper is particularly designed to include indicators which, we believe, are relevant to the macroeconomy of Pakistan. For instance, with Pakistan being a developing country, the support of money supply to accommodate foreign aid is extremely crucial in the steady growth of the economy. Furthermore, the accommodation of monetary policy to service the debt burden is equally important in the growth process. Thus, unlike other policy reaction functions [constructed for developed economies e.g., Havrilesky (1967) and Froyen (1974)], our model will incorporate those variables which we believe are important and relevant for the economy of Pakistan.

Another important *innovation* in our paper is the estimation of an alternative policy reaction function (APRF) which is constructed on the assumption that the policy-makers (i.e., the State Bank) are rational. Here, rationality implies that the State Bank is forward-looking and sets its monetary targets on the basis of its perceived or expected notion (rather than lagged values as assumed in other reaction functions) of the macroeconomic targets variables. Since these expected target variables are unobserved at the beginning of time t, they are, in turn, forecasted on the basis of current available information (which not only includes lagged information of the forecasted variable alone but also takes into account information from other available variables as well) to the policy-makers.

Section 2 provides a justification for the variables included in the policy reaction function. The estimation procedure is discussed in Section 3 while the

[1]The two large macroeconomic models developed in Pakistan are PIDE (1983) *Macroeconometric Model* and AERC (1988) *Macroeconometric Model.*

[2]One exception been the small rational expectations macroeconomic model developed by Hasan (1987). Although, Hasan (1987) explicitly considers a monetary policy reaction function, his model nevertheless does not incorporate some of the target variables (as shown in the text) that we feel should be relevant for Pakistan.

data and results are presented in Section 4. Section 5 provides the conclusion of the paper.

2. SPECIFICATION OF THE MONETARY POLICY REACTION FUNCTION

In this section, we discuss the two types of reaction functions estimated in the paper and we name them (a) standard policy reaction function (SPRF) and (b) alternative policy reaction function (APRF).

Standard Policy Reaction Function (SPRF): It is generally argued that a well-specified monetary reaction function is expected to capture the main thrust of monetary policy. A preferred policy reaction function should be one that takes into account both policy and non-policy (which may not be completely known to the policy-maker) activities of the economy.

The specification of our standard policy reaction function, estimated at time t, is given below:

$$MB_t = \alpha_0 + \alpha_1 GNP_t + \alpha_2 UNM_t + \alpha_3 INT_t + \alpha_4 TIDBT_t + \alpha_5 BD_t + \alpha_6 INF_t + \alpha_7 EXR_t + \alpha_8 FINT_t + \alpha_9 BP_t + \alpha_{11} D_t + \xi_t; \quad \ldots \tag{1}$$

where the variables are as defined below and ξ_t is the random error term with zero mean and constant variance.

MB	Monetary base;
GNP	Gross national product;
UNM	Unemployment rate;
INT	Interest rate on long run bond;
TIDBT	Federal Government debt, held by public;
BD	Budget deficit;
INF	Inflation rate;
EXR	Total external resources;
FINT	Effective foreign interest rate. This variable is created by dividing debt services by total outstanding foreign debt;
BP	Balance of trade deficit; and
D	Dummy variable. This variable has value equal to 1 for 1960–71 and 0 for 1972–86.

In our standard reaction function, variables such as unemployment (*UNM*), budget deficit (*BD*), internal debt (*TIDBT*) and gross national product (*GNP*)′ are expected to positively influence the monetary policy. On the other hand, the inflation rate (*INF*) and interest rate (*INT*) are expected to have a negative effect on the monetary base. The proposed signs for these variables in the preferred monetary reaction function can be justified on the grounds that in the event of rising unemployment, a large budget deficit, heavy internal debt and steady high growth of the GNP, the monetary base (*MB*) must increase to accommodate these changes, while rising inflation and interest rates may be tackled by a contractionary monetary policy. Furthermore, in order to accommodate higher balance of payments deficit the monetary base should be shrinking thus the coefficient of the balance of payments deficit (*BP*) variable will be negative in the policy reaction function.

As mentioned earlier, since foreign aid and foreign debt servicing are important factors in the process of growth and development in Pakistan, we also take these variables into consideration in the construction of the reaction function. External resources (*EXR*) have been taken as a proxy for foreign aid while the effective foreign interest rate (*FINT*) is the proxy for external debt servicing. We expect the former variable to have a positive effect while the latter to have a negative influence on monetary policy. The intuitive explanation for such relationships are as follows: For an increasing inflow of *EXR* to have meaningful effect on the economy an accommodative policy is required; and that due to a high foreign effective interest rate, there will be an outflow of domestic financial assets causing a decline in the monetary base.

Alternative Policy Reaction Function (APRF): Following the practices of other studies [e.g., Havrilesky (1967) and Froyen (1974)], our standard monetary policy reaction function included, on the RHS, the contemporaneous values for the target variables. In this paper, however, we argue that if the Central Bank is rational and forward-looking then it should set its monetary targets on the basis of future expected values rather than contemporaneous values (as in the case of SPRF) of key macroeconomic target variables. This is so because, at the beginning of period *t* when the Central Bank sets the monetary targets, it is very unlikely that complete knowledge about the RHS contemporaneous variables in Equation (1) would be available to the Central Bank. But then the Central Bank can always make forecasts about those unknown target variables better than other agents in the economy. If we assume that the Central Bank behaves rationally that is, it forms expectations about the unknown contemporaneous variables on the basis of all current available information, then our alternative policy reaction function can be written as follows:

$$MB_t = \beta_0 + \beta_1 GNP^e_{t,t-1} + \beta_2 UNM^e_{t,t-1} + \beta_3 INT^e_{t,t-1} + \beta_4 TIDBT^e_{t,t-1} + \beta_5 BD^e_{t,t-1} + \beta_6 INF^e_{t,t-1} + \beta_7 EXR^e_{t,t-1} + \beta_8 FINT^e_{t,t-1} + \beta_9 BP^e_{t,t-1} + \beta_{11} D_t + \xi_t ; \quad \ldots (2)$$

$$X_t = X^e_{t,t-1} + v_t ; \quad \ldots (3)$$

$$X^e_{t,t-1} = E\left[X_t \mid \Phi_{t-1}\right] \quad \ldots (4)$$

$$\Phi_{t-1} = \left[\begin{array}{l}\text{lagged values of all the RHS variables including} \\ \text{MB plus the lagged values of the MB}\end{array}\right] ; \ldots (5)$$

where $X^{\varepsilon}_{t,t-1}$ represents the expected value of X based on information set (Φ_{t-1}) at t–1 and ξ_t and v_t are white noise random variables. Equations (3), (4) and (5) provide the definition of rational expectations.[3] Equation (3) simply states that a rational agent's forecast, based on available information $[\Phi_{t-1}]$, about an unobserved expected variable $[X^e_{t,t-1}]$ should deviate from its true value by a random error only.

We estimate the two policy reaction functions represented by Equations (1) and (2) using appropriate estimation techniques as discussed in the next section.

4. ESTIMATION PROCEDURES

Ridge Regression (RR): Since the RHS variables in Equation (1) are all exogenous, it may appear that a simple ordinary least squares (OLS) technique will be sufficient to produce unbiased estimates for the parameters of SPRF. However, since some of the RHS variables in Equation (1) [e.g., *GNP, INF, UNM*] are expected to be correlated with each other, this may pose a problem of multicolinearity if an OLS method is adopted to estimate Equation (1). There are, at least, four alternative traditional strategies, that can be followed to avoid such

[3]For a detailed discussion on the methodology of rational expectations, refer to Hasan (1987).

problems of multicolinearity. The four alternative techniques are: (a) obtaining more data, (b) using exact linear restrictions, (c) applying linear restrictions, and (d) employing biased estimation methods. It is now well-known that all these alternative techniques have their adverse consequences and thus the results produced from such methods should be interpreted with caution. In this paper, we have opted in favour of a *Ridge Regression* (RR) *method* to solve the multicolinearity problem. Though it is true that *Ridge Regression* produces biased estimator (β), it is, nevertheless, hoped that the variance generated from this estimator is small enough to compensate for the bias such that the root mean square error (RMSE) from RR is lower than that of OLS. The RR estimator can be written as:

$$\hat{\beta}(k) = (X'X + kI)^{-1} X'y \quad \text{... ... ...} \quad (6)$$

where X is a vector of RHS variables and k is a positive constant and is commonly known as shrinkage or biasing parameter. In order to implement the RR technique, all one needs is to select a value for k for which RMSE of $\hat{\beta}(k)$ is less than that for the OLS estimator.

McCallum's Single Equation Instrumental Variable (SEIV) Method: In order to estimate APRF, the unobserved rational expectations variables in Equation (2) are first replaced by their *ex post* values, so that Equation (2) involving all observed variables can be written as:

$$\begin{aligned} MB_t = {} & \beta_0 + \beta_1 GNP_t + \beta_2 UNM_t + \beta_3 INT_t + \beta_4 TIDBT_t + \\ & \beta_5 BD_t + \beta_6 INF_t + \beta_7 EXR_t + \beta_8 FINT_t + \beta_9 BP_t + \\ & \beta_{11} D_t + \textit{composite error}\,; \quad \text{... ... ...} \quad (7) \end{aligned}$$

This substitution induces an *"error in variables"* problem, since the RHS variables are now correlated with the *composite error* term. It has been proposed in the literature that we estimate Equation (7) by an instrumental variables technique, with instruments of the RHS variables being defined as the predicted values of the variables itself which are estimated by regressing the observed values on the elements of the information set.

5. DATA AND RESULTS

DATA: The annual data used in this study spans over a sample period from 1960 to 1986.[4] While constructing most of our time-series data on different variables, we were careful in taking out the effects of former East Pakistan (now Bangladesh).

Results: Table 1 reports regression estimates of the *Standard Policy Reaction Function* (SPRF) while the parameter estimates of the *Alternative Policy Reaction Function* (APRF) are given in Table 2.

In Table 1, SPRF has been estimated in two ways: (a) once using an Ordinary Least Squares method; and (b) by employing the *Ridge Regression* technique to take care of the multicolinearity problem. The estimated regression equations in both cases seem to be statistically significant (high F-values), have high explanatory powers (99 percent R^2) and have no apparent serial correlation problem. Although most of the parameters estimated by either OLS or RR have the correct expected signs, only a few among them turned out to be statistically significant. It is interesting to note that after correcting for the multicolinearity problem, only three variables remained significant as opposed to four variables in the case of OLS regression. The three significant variables were *GNP, UNM* and *INT.* Indeed, these variables should play an important role in explaining the monetary base because a viable monetary policy must accommodate a high rate of *output growth* and *full employment* [e.g., see Gupta (1979)]. However, it seems counter-intuitive and contrary to the stylized fact to observe the other relevant variables namely budget deficit (*BD*), government debt (*TIDBT*), external resources (*EXR*) or foreign reserves and foreign debt servicing to be unimportant in explaining the monetary policy reaction function. In fact, in this context Pakistan Economic Survey, 1987-88 (p.73) noted: "*Monetary policy (in Pakistan)... has played an accommodating role to fiscal policy... and by budgeting for credit to be provided to the public sector and for changes in foreign exchange reserves.*" One can further argue that the State Bank, on many occasions, attempted to counteract inflation by pursuing policies which have kept the growth of cash balances, on average,

[4]The choice of this period roughly coincides with the four political regimes in Pakistan which is further sub-divided into two subperiods based on their similar monetary policy practices. The period 1960–71 [Ayub Khan and Yahya Khan regimes] was characterized by remarkable extension in money and capital markets, banking and credit institution, more reliance on market mechanism and sharp increase in saving and postal deposits. During this period, private sector was responsible for the changes in monetary assets. To control the expansionary situation, particularly, during the 1965 War State Bank followed a restrictive policy by increasing the bank rate. The period (1971–86) which comprises of Zulfikar Ali Bhutto and Ziaul Haq started after the separation of East Pakistan. This Period is characterized by the liquidity shortage in beginning, 125 percent devaluation in currency in 1972, oil shocks in 1973 and nationalization of banks and other industries. During this period government's overspending along with the rise in world prices were the major causes of inflation. In order to fight this situation bank rates margin requirement and liquidity ratio were increased.

Table 1

Regression Estimates of the Standard Policy Reaction Function (SPRF)

Variables	OLS EQ.1	Ridge Regression EQ.2
[illegible]	426.70 (0.46)	1146.63 (1.21)
GNP	0.12 (10.70)*	0.12 (11.09)*
UNM	270648.00 (3.03)*	221813.40 (2.76)*
INT	– 81755.00 (2.66)*	– 75529.50 (2.59)*
TIDBT	0.17 (1.41)	0.069 (0.50)
BD	0.19 (1.56)	0.06 (0.44)
INF	– 203.00 (0.03)	6408.70 (1.00)
EXR	0.24 (2.06)*	0.188 (1.48)
FINT	16.50 (0.25)	– 5.55 (0.08)
BP	–0.09 (0.98)	– 0.16 (1.43)
D	– 263.01 (0.27)	1405.30 (1.09)
R^2	0.99	0.99
SE	908.00	911.50
DW	2.7	2.6
F-value	1532.0	–
RMSE	712.0	–

Notes: The numbers in the parentheses are the absolute values of the *t*-statistics. One asterisk indicate significance at 95 percent while two asterisks represent significance at 90 percent.

Table 2

Regression Estimates of the Alternative Policy Reaction Function

Variables	One Lag EQ.3	Two Lags EQ.4
[illegible]	4293.01 (3.22)*	3864.74 (2.72)*
GNPF	0.10 (7.50)*	0.103 (11.04)*
UNMF	354311.71 (3.01)*	280853.82 (2.85)*
INTF	149139.44 (3.42)*	– 139117.42* (4.36)
TIDBTF	0.47 (1.95)**	0.60 (3.70)*
BDF	0.47 (2.02)*	0.53 (3.40)*
INFF	17266.68 (1.68)**	20010.85 (3.12)**
EXRF	0.37 (2.58)*	0.36 (3.70)*
FINTF	– 227.93 (1.81)**	– 176.48 (1.46)
BPF	0.03 (0.27)	0.10 (0.33)
D1	– 962.68 (1.04)	– 401.3 (0.59)
R^2	0.99	0.99
SE	879.44	634.48
DW	1.68	2.12
F-value	1634.35	2855.84
RMSE	667.00	465.00

Notes: The numbers in the parentheses are the absolute values of the *t*- statistics. One asterisk indicate significance at 95 percent while two asterisks represent significance at 90 percent.

below the growth rate of real *GNP*.

The question then arises as to why these variables (e.g. *BD*, *TIDBT*, *EXR* and *INF*) were insignificant in the *SPRF*. We believe that introducing these variables in a contemporaneous form in the standard policy reaction function [Equation (1)] generated a problem of simultaneity bias which in turn increased the standard error of the parameter estimates thereby making these coefficients statistically insignificant.

In order to avoid the problem of simultaneity bias, one can perhaps simply use the lagged values of these contemporaneous variables in the standard policy reaction function. We, however, argue that the State Bank is rational and at the beginning of period *t*, the Bank uses the forecasted values for these unobserved contemporaneous variables. Since the Bank is assumed to be rational, it, therefore, forms expectations about these unobserved variables on the basis of current available information which includes the past values of all the *RHS* contemporaneous variables.

The regression estimates of the alternative policy reaction function are reported in Table 2. The unobserved expected variable in Equation 3 in Table 2 has been predicted using the information set containing only one lagged value of all available variables while in Equation 4 two lagged values were used in the information set. It is interesting to note that now, as expected, all other relevant variables (e.g. *BD*, *TIDBT*, *INF* and *EXR*) along with *GNP*, *UNM* and *INT* are statistically significant and have the correct signs.

We also compute the root mean square error (*RMSE*) for both types of reaction functions, in order to compare the within sample forecasting power of these two policy reaction functions. Interestingly enough, the *RMSE* for the alternative policy reaction function (*APRF*) turned out to be much smaller than that of the standard policy reaction function (*SPRF*) providing a further support to the proposed *APRF*.

6. CONCLUSIONS

The extent to which the monetary policy reaction function is endogenously determine within the macroeconometric models is very crucial and can have important implications in the proper interpretations of policy effects. It is thus important to properly specify and estimate the policy reaction function.

In this study we estimated a policy reaction function for Pakistan incorporating variables which are important and indigenous to the economy of Pakistan. We further argue, in this paper, that the standard practice of using the contemporaneous macroeconomic target variables on the *RHS* of the policy reaction function may not be justifiable on econometric and intuitive grounds. We thús proposed an alternative policy reaction function wherein the contemporaneous values of the *RHS* variables are replaced by their expected values. The estimated alternative policy reaction function not only produced parameter estimates which are statistically significant and consistent with the stylized facts but its forecasting power (measured by *RMSE*) was also considerably superior to that of the standard policy reaction function.

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